



Base Course Inspection

Georgia Department of Transportation
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FORWARD

Base Course Inspection has become a complex and highly technical task. It is necessary for today's inspector to be thoroughly knowledgeable about all materials, tests, machinery, processes, and the sequence of operations involved in base course inspection. A vital quality demanded of the inspector is the ability to make accurate decisions based on knowledge of his field and sound judgment.

TO THE STUDENT...

This study course is designed to provide the background knowledge which, when coupled with experience in the field, is needed to properly inspect base course construction in Georgia.

This is a self-instructional study course, which allows you to proceed at your own speed. The course is constructed in a logical sequence, so that at each point, in the course you will have been given all the information needed to understand what is being discussed.

The idea behind this method is for you to read and study the information, actively participate by writing or checking off answers to questions, then find out immediately if you are correct. This method reinforces what you have read and enables you to retain what you have learned for a longer period of time. The retention of information from a self-instructional study course should be far greater than from a lecture or textbook.

To get the most from this course, start at the beginning. Read each section as it comes; preparing you for the next section. To make reading easier, the information is divided into frames. At the end of some frames, you will find questions. By answering these questions, you will be able to retain what you have just read longer than by lecture or discussion.

The answers to these questions are as follows: If the questions are on an odd page, look on the following odd page. If the questions are on an even page, turn that page back and look at the preceding even page. To explain further, the answers to questions on page four can be found on page two.

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CHAPTER 1: OVERVIEW

INTRODUCTION TO BASE COURSE

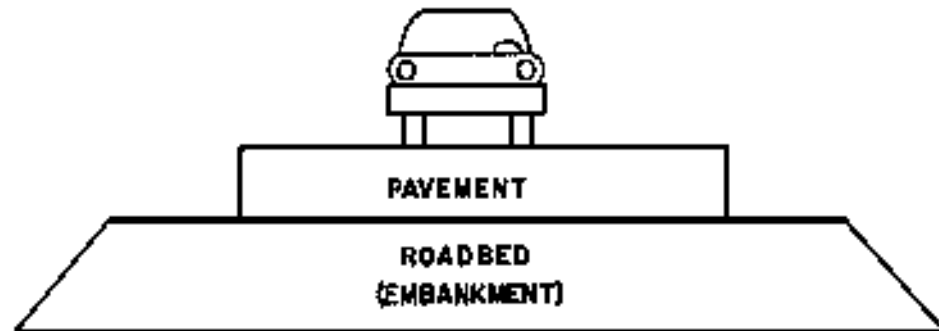
In this introductory Chapter, you should get a general idea of what base course construction is all about and the various types of base courses that are constructed in Georgia. The second Chapter deals with the procedures that must take place before the base course is actually constructed and your role as the inspector. In Chapter 3, we will discuss the actual construction procedures that take place after all of the preliminary steps have been taken. Some of the procedures from Chapter 2 and Chapter 3 may actually take place at the same time. For example, after a sufficient amount of the roadbed has been prepared for placement of the base course, construction on that portion will begin. Meanwhile, the contractor is preparing another section at the same time. Chapter 4, which is the final Chapter, covers the acceptance of the completed base course. You have an important role as the inspector in each phase of base course construction, so let's begin now with the elements of a roadway.

1-2. sometimes

The Elements of a Roadway

- 1-3. 1. pavement
2. shoulder
3. base course

The base course is actually a part of the pavement that is the finished cover or riding surface of the roadway. It bears the weight of the traffic load, and evenly distributes the weight to the foundation of the road.



The second part of the roadway is the roadbed, or embankment. It is the foundation, and it provides support for the pavement.

The shoulders are the third main part of the roadway. Shoulders provide safety and lateral (side) support for the pavement.

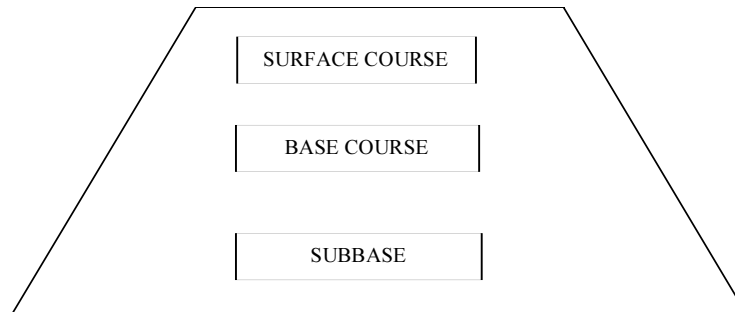


1-1 MATCH THE PARTICULAR PART OF THE ROADWAY WITH ITS FUNCTION.

- | | |
|------------------|---|
| ___ 1. Pavement | A. To provide lateral support and safety |
| ___ 2. Shoulders | B. To bear and distribute the weight of the traffic load. |
| ___ 3. Roadbed | C. To support the pavement and shoulders |
-

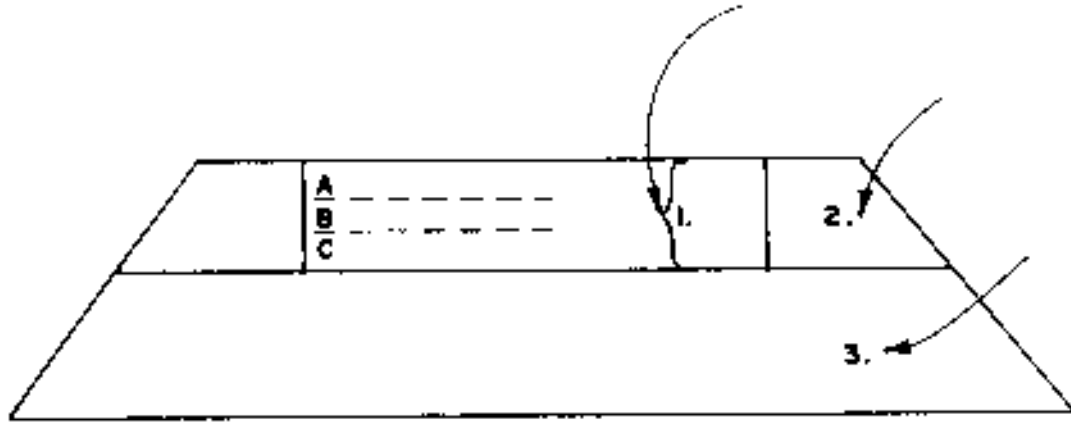
Pavement is constructed in separate layers. The top layer is called the surface course. It takes all the wear and tear of the traffic load. The second layer is the base course. This is the layer that you will be inspecting. The bottom layer of pavement is called the subbase. Since the subbase is built and inspected just like the base course, we will only discuss base course inspection. The traffic load on a particular road may not necessitate all three courses.

Pavements that carry a heavy traffic load usually contain a surface course, base course, and one or more subbases. Pavements that carry a light traffic load contain only a surface course and base course.



CHOOSE THE CORRECT ANSWER:

- 1-2 It is (sometimes / always) necessary to have a subbase.
- 1-3 Label the three main parts of a road and the three layers of pavement on the diagram below.

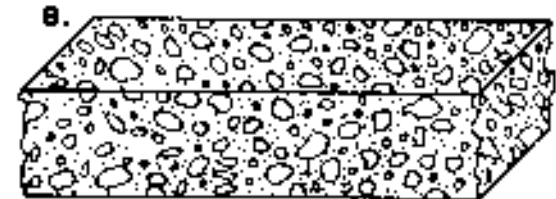


- 1-5. 1-Yes
2-Yes
3-No
4-No
5-Yes

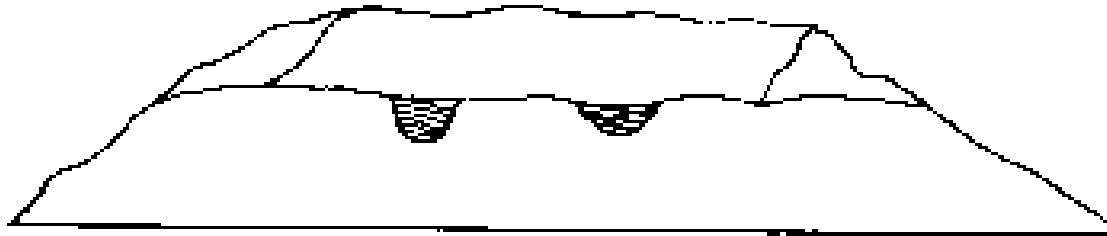
Basics of Constructing a Stable Roadway

For a road to be stable, each part that we have just discussed must be stable in itself. There are four main procedures that help us in constructing a stable roadway. We will discuss each one of the procedures in detail in Chapter 3 which deals specifically with base course construction; however, let's take a general look at these procedures now.

We mix the roadway materials to obtain a uniform mixture of particles. Which material below is mixed properly?



We need a uniform mixture of particles to help prevent a road from developing failures and looking like this:

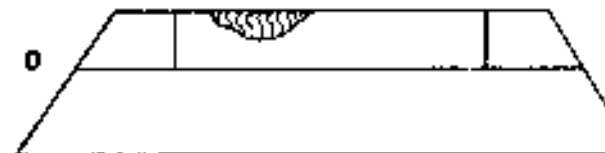
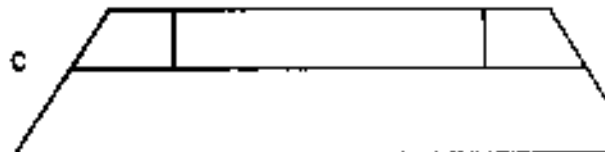
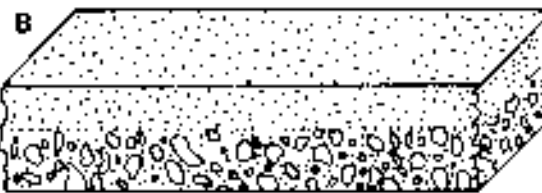


1-4 Match column "A" picture:

Column A

Column B

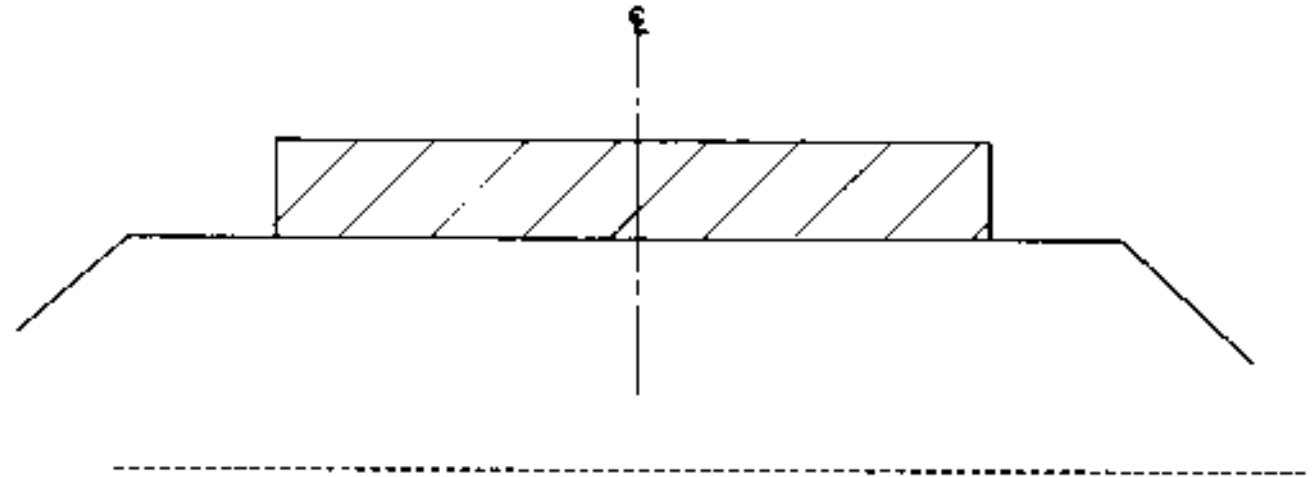
- _____ 1. A pavement failure
- _____ 2. Non-uniform particle distribution
- _____ 3. Cross-section of stable roadway
- _____ 4. Uniform particle mixture



- 1-1. 1-B
2-A
3-C

Roadway materials are spread in layers, or lifts. Each lift should have dimensions that are uniform and conform to plan typical section.

Here is a cross-section of a single lift:



1-8. The elevation difference between shoulder and centerline

1-9. The slope from centerline to shoulder

1-10. The plan typical section

Each lift should have uniform thickness and width before we can say that it is spread properly. No lift should be spread on top of a non-uniform lift.

ANSWER YES OR NO:

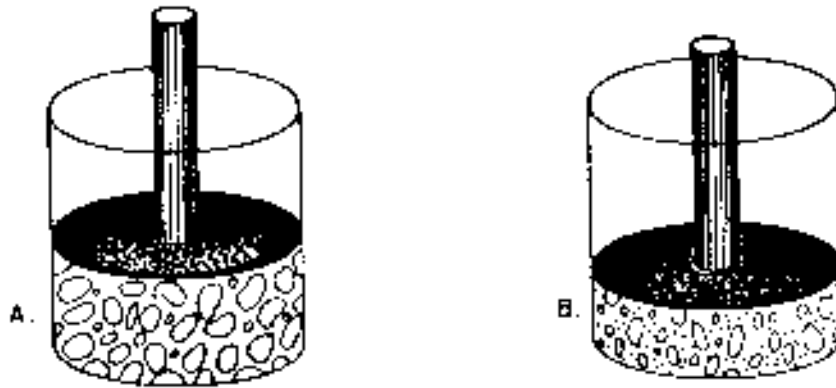
1-5 Which three of the following five reasons are why loose roadway mixtures should be spread uniformly.

- ____ 1. To obtain uniform thickness and width
- ____ 2. To prevent failures
- ____ 3. To obtain proper proportioning
- ____ 4. To obtain maximum gradation
- ____ 5. To obtain stability

Material that is compacted (dense) will support more weight than uncompacted material.

ANSWER THE QUESTION:

1-6 Which sketch below shows material that is compacted?



1-4. 1-D
2-B
3-C
4-A

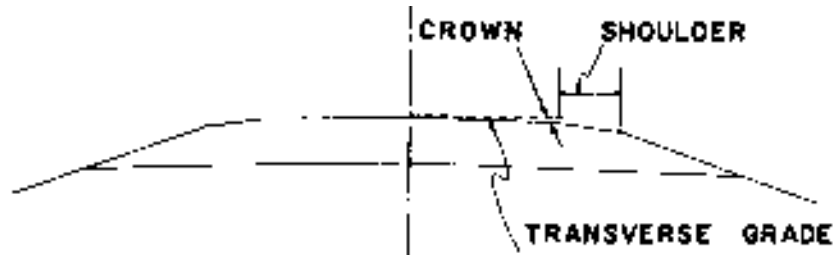
Each lift of roadway material is compacted so that it will be dense. Each lift should have the required density as set forth in the appropriate section for bases of the Standard Specifications for Roads and Bridges. Required density is usually 100%.

ANSWER THE QUESTION:

1-7 What will probably happen to a lift that is not compacted to its required density?

- ☐ Nothing will happen.
- ☐ The lift could be unstable.
- ☐ The lift could develop failures.
- ☐ The lift could weaken any lift(s) placed above it.

A properly finished road must conform to plan typical section. It must have the same crown and grade as the plans.



The crown is the elevation difference between the centerline of the road and the shoulder.
The transverse grade is the slope of the road from the centerline to the shoulder.

FILL IN THE BLANK(S):

- 1-8 The crown of a road is _____
- 1-9 The transverse grade of a road is _____
- 1-10 A properly finished road must have the same crown and grade as _____

One way in which the proper grade and crown are achieved is by fine-blading, which is the scraping off of excess compacted material in order to trim the roadway to the planned dimensions. (Fine blading should be a trimming operation - not a filling operation.)

FILL IN THE BLANK(S):

- 1-11 Fine-blading is part of the _____ operation.
- 1-12 Fine-blading is the _____ of excess compacted material.
-

After fine-blading, the loose material must be brushed away with a special piece of equipment so that the asphaltic material that is sprayed on the completed base course will stick. Depending on the type of base course, the asphaltic material used can either be an emulsion, a prime coat, or a tack coat. (We will go into more detail later as to when the different materials are used). The main purpose for spraying asphaltic material on the completed base course is to protect the base course until surfacing is applied.

FILL IN THE BLANK(S):

- 1-13 Loose material remaining after fine-blading must be _____ so that _____ will stick to the completed base course.
- 1-14 Three types of asphaltic materials used to protect the base course are _____, _____, and _____.
-

Another step in the construction of a base course is the construction of the shoulder base. At times, the base course is extended into the shoulder area forming one continuous unit. Another method requires a special piece of equipment that deposits material off the base course edge then the shoulder base material is shaped, compacted, fine-bladed, and is protected with asphaltic material.

- 1-15 Put these base course construction steps in their usual order:
- _____ a. applying the asphaltic materials
 - _____ b. brooming the surface
 - _____ c. fine-blading
 - _____ d. compacting the base course
 - _____ e. completing the shoulders

1-6. B

1-7. B

Special equipment is used for each construction procedure that we have talked about; we will discuss the equipment required as each procedure is covered in detail in Chapter 3. This portion of the manual is to familiarize you with general concepts and practices.

TYPES OF BASE COURSES

There are four general types of base courses:

raw, untreated soil or soil aggregate
raw, untreated aggregate
stabilized soil and aggregate
asphaltic concrete

1-16. graded aggregate

The "multi-layered" base course is a combination of these four types.

1-17. sand-clay

Raw, Untreated Aggregate Base Course

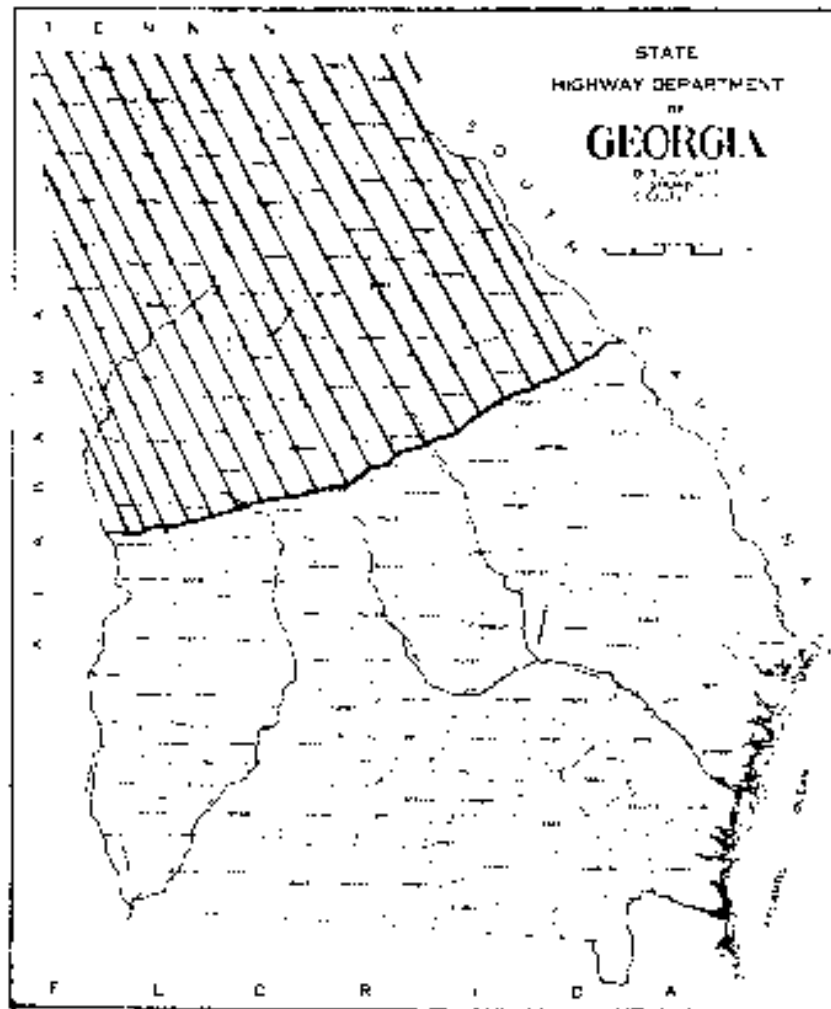
Raw means that no chemicals have been added to the aggregate. The three types of aggregate materials that can be used for base courses in Georgia are:

1-18. components
measuring

sand, clay or soil aggregate
chert
graded aggregate

1-19. sands
25%

This map illustrates the materials common to the northern and southern parts of Georgia.



SOIL AGGREGATES, CHERT AND GRADED AGGREGATE



SAND-CLAYS, SOIL

1-11. Trimming

1-12. Scraping off

1-13. Brushed away
Asphaltic material

1-14. Emulsion
Prime
Tack

1-15. A. 4
B. 3-
C. 2-
D. 1-
E. 5-

1-20. Add enough of the material that it lacks to bring it to specifications.

1-21. 1-PR
2-A
3-PR
4-A
5-B
6-B

1-22. Components must contain particles of specific sizes and a certain proportion of each size.

1-23. Sieving

ANSWER THE QUESTION(S):

1-16 Which raw aggregate do you suppose is most commonly used in north Georgia?

1-17 How about the raw aggregates most common to the coastal (southern) counties?

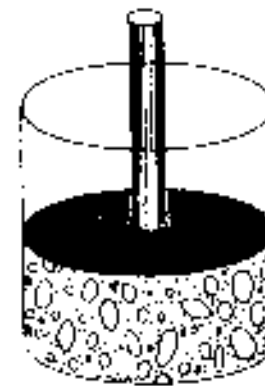
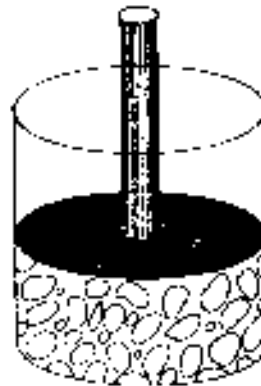
Each raw aggregate material is made up of components. For example, the base course material, graded aggregate, is made up of two components: coarse and fine aggregate. The mixture of various aggregate components is not a random process, but rather a measured, calculated one. The Standard Specifications provide information for mixing the various components. See Sections 814, 815 and 816 for the gradation ranges.

FILL IN THE BLANK(S)

1-18 Raw aggregate base courses are made up of _____ which have been mixed by _____ a certain amount of each aggregate.

1-19 Topsoil/sand-clay base courses are composed predominantly of _____ with up to _____ clay.

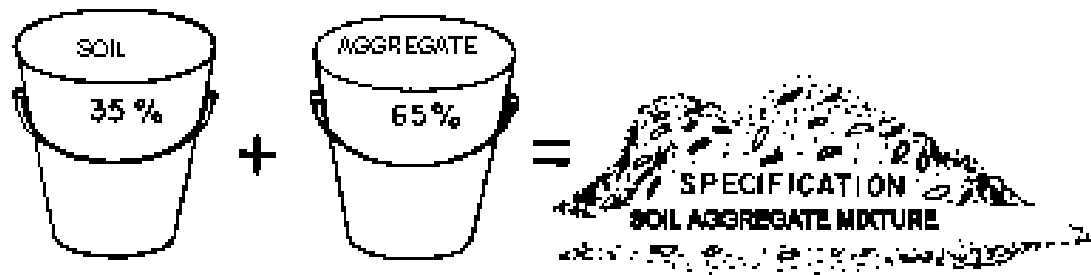
Look at these base course materials:



Left View - material having unmeasured components. The unmeasured mixture contains too many large particles and not enough small particles to fill up the large spaces, or voids, between these particles. Compacting this material would be like compacting a can of marbles. The required density would not be reached.

Right View - material having measured components. There are enough small particles to fill the voids between the large particles. A greater density is achieved and therefore, a more stable material.

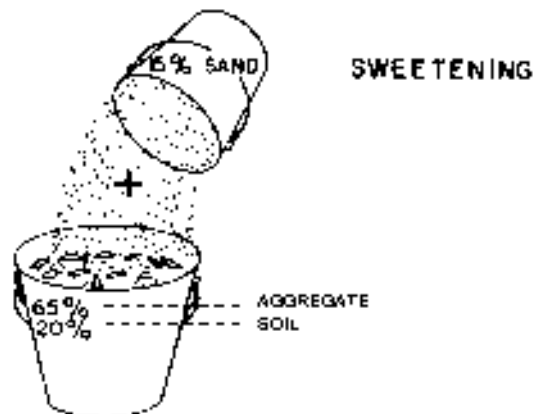
A raw aggregate mixture may either be an artificial mixture or a pit-run mixture. To make an artificial mixture we take a specified percentage of one component and mix it with a specified percentage of another.



We can get by with less work if we can find a pit-run mixture of raw aggregate. Unlike an artificial mixture, a pit-run mixture is a natural deposit. If the pit-run mixture meets specifications, we can use it for base course material. If the mixture does not meet specifications it is deficient, meaning that it lacks enough of one or more components.

Adding components to a deficient mixture is called sweetening. We sweeten by adding necessary amounts of the insufficient components to the mixture.

For example, 65% AGGREGATE + 35% SOIL = SOIL-AGGREGATE



ANSWER THE QUESTION(S)

1-20 What do you think must be done to a deficient pit-run mixture?

1-21 Write "A" if the property describes an artificial mixture or "PR" if it describes a pit-run mixture. Write "B" if both.

_____ 1. natural mixture

_____ 2. man-made mixture

_____ 3. sweetening is usually required

_____ 4. usually a specification mix

_____ 5. aggregate material

_____ 6. must meet specifications before going into base course

1-28. Plasticity Index =
Liquid Limit - Plastic Limit

1-29. Water
Stick together

1-30. 9

1-31. Cement, lime, or bitumen has
been added to a increase the
strength of base course material

In addition to mixing requirements, raw aggregate materials must also meet gradation requirements, that is, the components must have particles of specified sizes and a certain proportion of each size particle. Gradation is determined by sieving (the passing of materials through a series of sieves having openings of various sizes). Aggregate particles fall through the sieve openings until they reach the sieves that are too small for them to pass through. Gradation is based on the percentage passing the required sieve.

FILL IN THE BLANK(S):

1-22 Gradation means _____.

1-23 Gradation is determined by _____.

Sieves are classified according to the size of the openings. For example, the 1½-inch sieve has openings 1½-inches square. The smaller the fractional designation of the sieve, the smaller the opening. When sieve openings become so small that the hole is no longer "fractional" they are referred to in number size, e.g. No. 4, No. 200., etc. When the sieve falls in this category, the larger the number of the sieve, the smaller the holes will be and there will be more holes. For instance, a No. 8 sieve will have 8 openings per linear inch. A No. 100 sieve will have 100 holes per linear inch. A square inch of a number 8 sieve would have 8 X 8 holes or 64 holes per square inch.

ANSWER THE QUESTION(S):

1-24 What type of material do you think could pass the No. 200 sieve?

1-25 Sieves are classified according to what?

Some other requirements of raw aggregate base courses concern the liquid limit and plasticity index of the materials. Special testing procedures, which we are not concerned with in this course, allow us to determine the liquid limit and plasticity index of a particular material.

The liquid limit indicates the maximum amount of water, in percent, which can be added to a material before it passes from a semi-solid to a liquid or flowing state. The Standard Specifications state that for a topsoil/sand-clay base course, the material which passes the No. 40 sieve must have a liquid limit of 25 or less.

FILL IN THE BLANK(S):

1-26 Liquid limit indicates the maximum amount of _____ which can be added to a material before it passes from a _____ to a _____ state.

1-27 The maximum allowable liquid limit for a topsoil/sand-clay base course is _____ .

1-37. Treatment
Soil or soil-aggregate

1-38. asphaltic concrete base
sand asphaltic base

The plasticity index is determined by first determining the plastic limit of a material. The plastic limit is the minimum amount of water, in percent, which must be in a material in order for the particles of this material to stick together, or be plastic.

The Plasticity Index = Liquid Limit - Plastic Limit

The Standard Specifications state that the materials in topsoil/sand-clay which pass the No. 40 sieve must have a plasticity index of 9 or less.

FILL IN THE BLANK(S):

1-28 The formula for the Plasticity Index is _____

1-29 The plastic limit is the minimum amount of _____ which must be in a material in order for the particles to _____.

1-30 The maximum allowable plasticity index of a sand-clay base course is _____

Stabilized Soil and Aggregate Base Courses

Soil or aggregate is stabilized by adding Portland cement, lime, or bitumen to it to increase the strength of the base course.

ANSWER THE QUESTION:

1-31 What is the difference between a raw and a stabilized material?

There are four types of stabilized base course materials used in Georgia.

- soil-cement
- cement-stabilized soil aggregate
- cement-stabilized graded aggregate
- lime stabilized soil or soil aggregate

Aggregates stabilized with cement or lime may either be pit-run or artificial.

The most common type of stabilized base course is soil-cement. The soil for soil cement is usually a special type referred to as "soil cement material." Soil cement material is classified as Class IIA or better as specified in section 814.02 of Standard Specifications.

Soil cement material for soil-cement shall have a liquid limit of 25 or less and a plasticity index of 10 or less. The Office of Materials and Research will determine the percentage of cement to be used in stabilizing the soil cement.

FILL IN THE BLANK(S):

- 1-32 The most common type of stabilized base course is _____.
- 1-33 Class IIA or better is a special classification of soil referred to as _____.
- 1-34 The amount of cement used in soil-cement is determined by the _____.

Another type of stabilized base course is cement-stabilized soil aggregate. The soil aggregate to be stabilized should have the same recommended mixing proportions and gradation requirements as the soil aggregate for raw aggregate base courses. However, the maximum allowable liquid limit for cement stabilized soil aggregate is 25, and the maximum allowable plasticity index is 9.

The percentage of cement required for stabilization of soil aggregate is usually 5% to 6% by weight.

FILL IN THE BLANK(S):

- 1-35 Cement-stabilized soil aggregate should have the same _____ and _____ of soil aggregate as that used for raw aggregate base courses.
- 1-36 The percentage of cement is usually _____ by weight.

The third type of stabilized base course is cement-stabilized graded aggregate. If graded aggregate is to be stabilized, the minimum amount of fine aggregate used is 30 percent by weight. The percentage of cement required for stabilization is usually 4% to 5%.

1-24. Dust from aggregate particles

1-25. The size of the openings

1-26. Water
Semi-solid
Liquid

1-27. 25

- 1-42. a. Pavement
b. Roadbed
d. Shoulders

- 1-43. a. Pavement

- 1-44. b. Fine blading
d. Applying prime coat

- 1-45. c. Select material

- 1-46. d. Pit-run

Lime-stabilized soil or soil aggregate is the last type of stabilized base course used in Georgia; however, it is not as common as some of the other stabilized bases. Lime is used more today for treatment of soils and soil aggregates than for stabilization of base course materials. For example, soils having a high Plasticity Index (P.I.) will absorb more water and swell easily. Before the soil can be used, the P.I. must be reduced. Lime treatment will help achieve this.

The soil or soil aggregate must have the same recommended mixing proportions and gradation requirements as for raw aggregate bases; however, when stabilized with lime, the maximum allowable L.L. (liquid limit) is waived, and the P.I. should be within a range of 6-20.

The percentage of lime required to stabilize soil or soil aggregate varies usually from 4% to 8% by weight.

FILL IN THE BLANK(S):

- 1-37 Lime is used more today for _____ of _____ than for stabilization; however, lime can be used in Georgia to stabilize.

Water is a necessary part of all base courses, as it allows the material particles to become dense. The Office of Materials and Research will determine the "optimum moisture content" for each type of base course material through special testing procedures.

Asphaltic Concrete Base Courses

The last type of Base Course that will be discussed is asphaltic concrete base courses. Requirements for base courses of asphaltic concrete are given in Section 400 of the Standard Specifications. Asphaltic concrete base and sand asphaltic base may be used for base courses.

Listed below are materials of which asphaltic concrete base is made.

Coarse Aggregates such as gravel, air-cooled blast furnace slag, crushed stone, or synthetic aggregates.

Fine aggregates such as crushed stone, crushed gravel, crushed slag, synthetic aggregate, natural sand, and blends of fine aggregates.

FILL IN THE BLANK(S):

- 1-38 _____ and _____ may be used for base courses.

Mineral filler is a very fine material used to fill air spaces, or voids, in the asphaltic mixture. The mineral filler that may be used for asphaltic concrete mix can be any of the following:

rock dust
slag dust
hydrated lime
fly ash
Portland cement
(or other approved material)

FILL IN THE BLANK(S):

1-39 A _____ is a fine dust used to fill voids. It is used when needed for an _____ mixture .

Just as the components of a raw aggregate base course must make up a certain percentage of the whole mixture, the components of an asphaltic concrete base course must also meet certain requirements by weight. The following chart is based on Section 828 of the Standard Specifications:

<u>Type</u>	<u>Asphalt Cement %</u>	<u>Aggregate%</u>	<u>% crushed retained on #4 sieve</u>	<u>% mineral filler minimum</u>
Base	4.00-5.5	94.5-96.0	as needed	as needed
Sand Asphalt Base	6.0-7.0	93.0-94.0	-----	-----

CIRCLE TRUE OR FALSE

1-40 True False Aggregates make up a smaller percentage than asphalt cement for asphaltic concrete base mixtures.

1-41 True False Mineral filler is used in sand asphalt base mixture.

1-32. Soil-cement

1-33. Soil-cement material

1-34. Office of Materials and Research

1-35. Mixing proportions
Gradation requirements

1-36. 5 - 6%

CHAPTER 1 REVIEW

CHOOSE THE CORRECT ANSWER(S):

1-53. b. Treatment of soils and soil-aggregates

1-54. a. Asphaltic concrete base

1-55. b. Mineral filler

1-56. The material passes from a semi-solid to a liquid or flowing state

1-57. Stick together or be plastic

1-42 Three main parts of a roadway are the:

- a. pavement
- b. roadbed
- c. subbase
- d. shoulders

1-43 The base course is actually part of the:

- a. pavement
- b. roadbed
- c. subbase
- d. shoulders

1-44 Two parts of the "finishing" process are:

- a. compaction
- b. fine-blading
- c. mixing
- d. applying prime coat

1-45 The material below that is not one of the three major types of base courses is:

- a. graded aggregate
- b. stabilized soil or aggregate
- c. select material
- d. asphaltic concrete

1-46 A graded aggregate or soil aggregate mixture that is a natural deposit is called:

- a. artificial
- b. deficient
- c. natural
- d. pit-run

1-47 Adding components to a deficient material is called:

- a. sieving
- b. sweetening
- c. grading
- d. compensating

1-48 Passing materials through a series of sieves (with openings of various sizes) determines the:

- a. moisture content of the material
- b. theoretical maximum density
- c. gradation of the mixture
- d. plasticity index

1-49 The No. 4 sieve has:

- a. openings 4 inches square
- b. 4 openings per square inch
- c. 4 openings per linear inch
- d. 16 openings per square inch

1-50 The plasticity index =

- a. liquid limit + plastic limit
- b. plastic limit - liquid limit
- c. liquid limit - plastic limit
- d. plastic limit X liquid limit

1-51 The most common type of stabilized base course is:

- a. soil-cement
- b. cement-stabilized graded aggregate
- c. cement-stabilized soil aggregate
- d. lime-stabilized soil or soil aggregate

1-52 Soil used in soil-cement is a specific type referred to as:

- a. special material
- b. soil cement material
- c. stabilizing soil
- d. type A-5

1-39. Mineral filler
Asphaltic concrete base

1-40. False

1-41. False

2-1. T

2-2. F

2-3. T

2-4. T

2-5. It decreases the depth of the base course.

- 1-53 Lime is used more today for:
- a. stabilization of base course materials
 - b. treatment of soils and soil-aggregates

- 1-54 Which type of asphaltic concrete mixture is used for base courses?
- a. asphaltic concrete base
 - b. sand asphalt base

- 1-55 A very fine material used to fill voids in some asphaltic mixtures is called:
- a. material filler
 - b. mineral filler
 - c. aggregate dust

FILL IN THE BLANK(S):

- 1-56 The liquid limit indicates the maximum amount of water that can be added to a material before

- 1-57 The plastic limit is the minimum amount of water, in percent, which must be in a material in order for the particles to _____

CHAPTER 2

PRECONSTRUCTION PROCEDURES

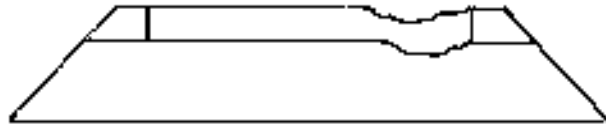
This Chapter includes those procedures that must take place before the actual construction of the base course can begin. If these procedures are not properly carried out, the probability of problems occurring later on is greater. As the inspector, you have an important role in the quality control of these procedures.

INSPECTING THE SUBGRADE AND REPAIRING DEFICIENCIES

Since a roadway may not always have a subbase, we will speak of constructing the base course on top of the subgrade. The subgrade is the top surface of a roadbed upon which the pavement and shoulders are constructed. One of your most important jobs as an inspector is to inspect the subgrade for defects that might indicate serious deficiencies in density and for surface irregularities caused by poor workmanship.

Deficiencies in density, or failures, are structural weaknesses in the roadbed and were caused by either excessive moisture or improper compaction procedures. Failures would probably show up during compaction of the roadbed. (The roadbed would yield under the heavy load of equipment). However, you should visually inspect the subgrade carefully for potential failures that did not show up during compaction.

Failures in the roadbed can cause defects in the base course and surface course.



Notice that the failure is actually in the roadbed, but it is also reflected in the subgrade and in the pavement surface.

1-47. b. Sweetening

1-48. c. Gradation of the mixture

1-49. c. 4 openings per linear in.
a. 16 openings per sq. in.

1-50. Liquid Limit - Plastic Limit

1-51. a. Soil-cement

1-52. b. Soil-cement material

CIRCLE TRUE OR FALSE:

- 2-1. True False Roadbed failures may cause failures in the base course.
- 2-2. True False The subgrade need not be inspected before the placement of base course material.
- 2-3. True False A roadbed, subbase, or base course is unstable if it has failures.
- 2-4. True False When a roadbed yields, it is a sign of structural weakness.
-

You will usually have to measure or survey to find surface irregularities in the subgrade. Such a deficiency can prevent a base course from conforming to specifications.

For example, this base course has been spread and compacted over a deficiency such as a high spot:



ANSWER THE QUESTION:

- 2-5 What effect does the above high spot have on the base course? _____

2-9. Decrease

2-10. Increases

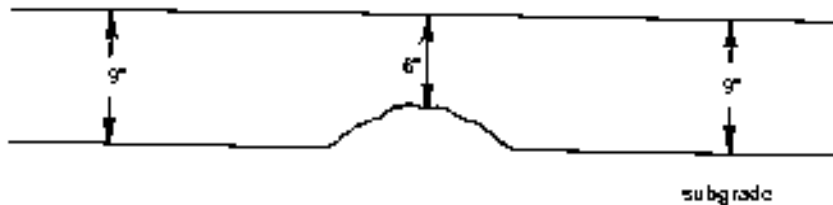
Deficiencies in the subgrade such as high spots, low spots, corduroy effects, improper elevation, improper grade, and improper cross slope can throw a base course out of tolerance, or can even lead directly to a failure. Plan tolerance is the range a base course may measure and still be within plan dimension. For example, the plan tolerance of the stabilized base course below is ½-inch above and ½-inch below the dimension of 8 inches.



FILL IN THE BLANK(S):

2-6 This means that the base course shown above can measure from _____ inches to _____ inches deep and still be within plan dimension.

The base course shown below has a plan depth of 8 inches and a plan tolerance of ½-inch over and ½-inch under plan depth.



USING THE DRAWING, ANSWER THE QUESTIONS:

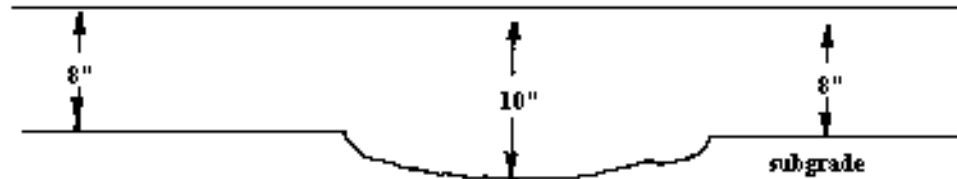
2-7 Is this base course within tolerance?

2-8 What has caused it to be out of tolerance?

CIRCLE THE CORRECT ANSWER:

2-9 A high spot in the subgrade will (increase / decrease) the depth of the base course and could cause it to be out of tolerance.

A low spot in the subgrade could throw the base course out of tolerance. For example:



2-13. b. high and uniform

2-14. T

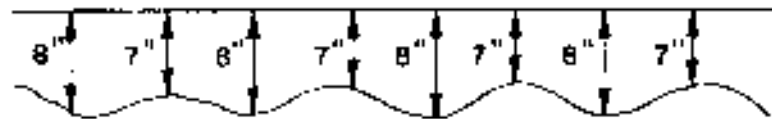
To stay within tolerance the base course must have even depth.

CIRCLE THE CORRECT ANSWER:

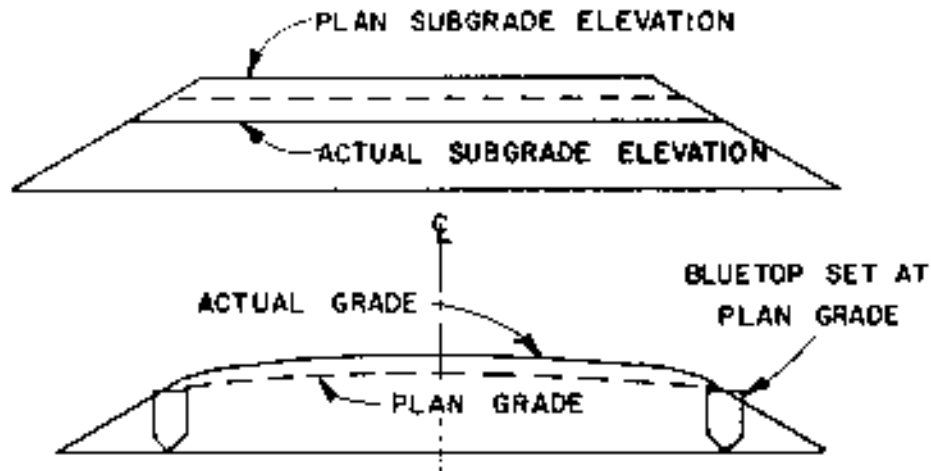
2-15. May not

2-10 A low spot in the subgrade (increases / decreases) the depth of the base course.

The corduroy effect is another type of deficiency. This is how a corduroy effect in the roadbed could affect the base course:



Improper elevation and improper grade are other deficiencies illustrated below:



CIRCLE THE CORRECT ANSWER:

- 2-11 In the top view the actual subgrade elevation is too (high / low) and will cause the base course to be too (thick / thin) when finished.
- 2-12 In the bottom view the actual grade is (above / below) plan grade. This deficiency will be found by (looking at the roadway / measuring or surveying).

The Project Manager and the Materials Office will decide how roadbed defects will be repaired. If you are serving in the capacity of inspector only, you should find out what methods and materials will be used for these repairs, and you should see that the contractor uses these methods and materials in accordance with the specifications. Be sure to document the location of the defect, the date, and the corrective action taken. All defects in the roadbed should be repaired before the base course is placed!

Defects in the roadbed can be repaired by either reworking and recompacting small areas such as soft spots or by removing and reworking larger areas (one or more stations). The repaired area must meet the same density requirements as the rest of the roadbed.

2-6. 7½ to 8½ inches

2-7. No

2-8. A high spot in the subgrade

2-21. 11 cubic feet

There are several ways that you, the inspector, can help prevent roadbed defects. If possible, you should close the roadbed to traffic (unless the contract requires that through traffic be maintained).

You should watch for heavy or overloaded roadway equipment that could cause ruts and depressions in the roadbed. You can't hold up the movement of material, but you can make sure the drivers don't continually ride through the same set of tracks. They should move around the roadbed rather than always use the same lane of travel.

If it rains, you can keep haul trucks and other heavy equipment off the subgrade until it dries.

You can also request that the contractor reduce the loads he carries. This way, the roadbed won't have to support so much weight. Finally, you should always make sure that water trucks do not flood the roadbed.

If the roadbed has all the following features, it will usually provide a firm foundation for the base course:

You want the entire roadbed to have a uniform appearance

You want it to have a high density to support the traffic load

You want a uniform density so it will be stable

You want a smooth riding surface, with no ridges or ruts

You want the subgrade to conform to plan grade

Preparation of the subgrade should be kept ahead of base course placement so that construction won't be held up. The contractor should have at least 1,500 feet of finished subgrade ready to receive the base.

CIRCLE THE CORRECT ANSWER(S)

- 2-13 Roadbed density should be:
- a. low and uniform
 - b. high and uniform
 - c. uniform but not necessarily high
 - d. uniform but not necessarily low

CIRCLE TRUE OR FALSE:

- 2-14 True False Subgrade and roadbed inspection must precede placement of the base course.

CIRCLE THE CORRECT ANSWER:

- 2-15 The depth of the base course (may / may not) be varied considerably to correct deviations in the subgrade.

2-16	A defective area that has been corrected should: a. meet the same density requirements as the rest of the roadbed b. conform to plan grade c. be allowed to set 3 days before being covered with base course material	
2-17	If not corrected, defects such as high spots, low spots, or corduroy effects could affect: a. the width of the shoulders b. the thickness of the base course c. none of the above	
2-18	The subgrade should conform to: a. plan grade b. original ground c. shoulder depth	
2-19	Deficient areas in the roadbed: a. should be reworked only. b. should be removed and reworked (if a large area). c. are not serious enough to rework if they are small areas. d. should be reworked and recompactd if they are small areas.	2-11. Low Thick
2-20	When inspecting the subgrade, you should make sure that: a. all Station stakes are in place b. it is finished far enough in advance of the placement of the base course to allow for proper inspection. c. it is finished far enough in advance of the placement of the base course to allow for necessary corrections to be made.	2-12. Above Measuring or surveying

CALCULATING MATERIAL QUANTITIES

After the subgrade has been inspected, it will be time to begin hauling in the base course material. The amount of each material that will be required depends on the dimensions of the section to be constructed. These dimensions are given in the plan typical section. Once you have this information you can calculate the spread, or the quantity of loose roadway material needed.

You will need to remember the following rules of rounding:

In intermediate steps, carry all figures two decimal places past the required rounding-off point (the required rounding-off point for problems concerning base course material is to the nearest tenth). Therefore, all intermediate steps should be carried to three decimal places.

Rounding-off should be done only in the final answer. If the last two digits are greater than 50, then round up.

Example: $6.286 = 6.3$

If the last two digits are less than 50, round down.

Example: 6.226 is rounded to 6.2

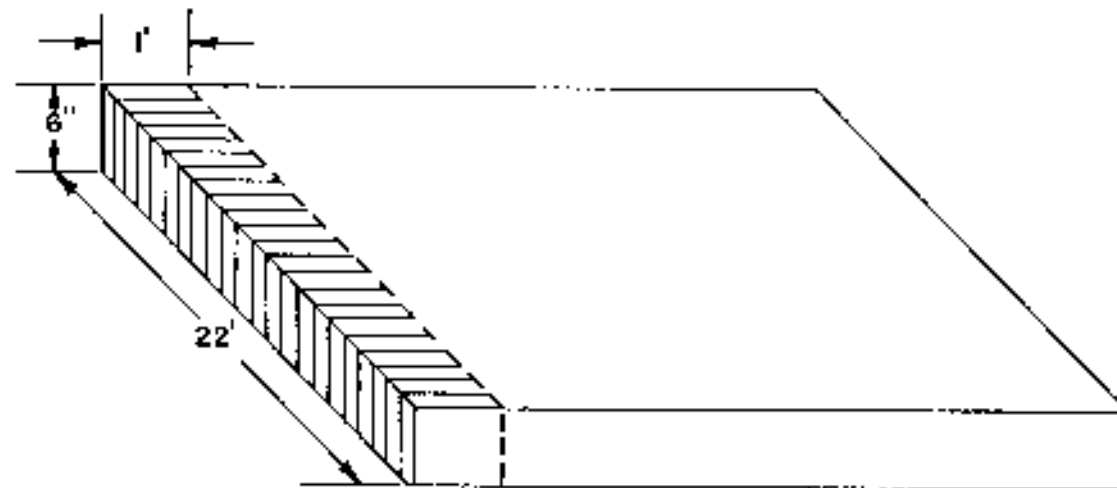
If the last two digits are exactly 50, round to the nearest even number.

Example: $6.250 = 6.2$

$6.350 = 6.4$

Calculating the Required Volume of Raw Material for Base Courses

The first step in finding the total loose material needed is to find the volume of one linear foot of a compacted section. You will find this volume by multiplying the plan dimensions (depth and width) by one linear foot. For example:



2-23. Particles are pressed closer together

ANSWER THE QUESTION(S):

2-21 What is the volume of the shaded area in the previous picture?

(Note: Change 6 inches to 0.5-foot)

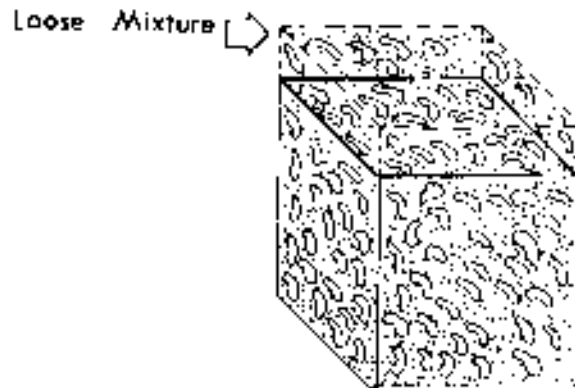
After you have found the total compacted volume for one linear foot of base course, you can easily find the total volume for any section. All you do is multiply the total compacted volume for one foot by the length of the section. The volume of one linear foot will be a constant for an entire job, unless the cross-section dimensions change.

ANSWER THE QUESTION(S):

- 2-22** If the total compacted volume for one linear foot of base course is 1 cubic foot, what is the total compacted volume for a 100 linear foot section of that base course?

Once you know the compacted volume per linear foot, you need to know the volume of loose material needed to fill that foot. The volume of a material shrinks after it is mixed and shrinks again after it is compacted. Therefore, the mixing and compacting procedures are going to affect the amount of material needed, and by understanding the mixing loss and shrinkage factor, you will be able to calculate just how much loose material will be required.

In a loose mixture there are many tiny voids, or spaces, between the particles. Often these voids are not apparent to the naked eye. Voids like these are caused by the shape of the particle. In a loose state, particles do not fit closely together.



2-16.

- a. meet the density requirements as the rest of the roadbed
- b. conform to plan grade

2-17.

- b. the thickness of the base course

2-18. a. Plan grade

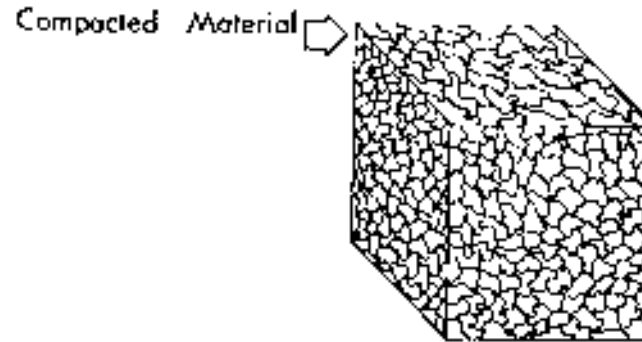
2-19.

- b. should be removed and reworked (if large area)
- d. should be reworked and recompact if they are small areas.

2-20.

- a. all station stakes are in place
- b. it is finished far enough in advance of the placement of the base course to allow for proper inspection.
- c. it is finished far enough in advance of the placement of the base course to allow for necessary corrections to be made.

During compaction, these particles are rearranged and pressed closely together. The voids are filled, so the same amount of material occupies less volume.



2-27. Soil particles

2-28. Voids

The shrinkage factor tells you just how much less space a certain volume of uncompacted material will occupy after it has been compacted. The formula for finding the compacted section volume is $\frac{\text{loose volume}}{(1 - \text{shrinkage factor})}$

FILL IN THE BLANK(S):

2-23 Material occupies less volume after compaction because _____

If the shrinkage factor for a particular material is 0.5, this means you will need 0.5 more loose material than the volume of the compacted section.

REQUIRED LOOSE VOLUME

$$\begin{array}{c}
 \text{100 Cu. Ft.} \\
 \text{[Irregular shape representing loose material]}
 \end{array}
 = 0.5 \times
 \begin{array}{c}
 \text{VOLUME OF COMPACTED SECTION} \\
 \text{[Rectangular shape representing compacted material]} \\
 \text{50 Cu. Ft.}
 \end{array}$$

CIRCLE THE CORRECT ANSWER:

- 2-24** To find the required loose volume (multiply / divide) the volume of the compacted section by one minus the shrinkage factor.
-

Find the required loose volume for a soil aggregate section of a roadway that is to be 20 feet wide and 6 inches deep. The shrinkage factor is 0.5.

- 2-25** Find the cubic feet:

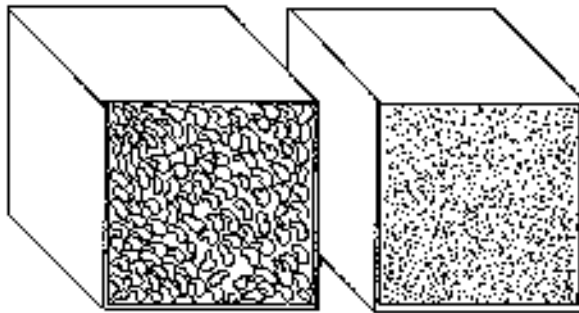
_____ cubic feet
(Note: Depth X Width X 1 linear foot)

- 2-26** Find the loose material needed for that volume:

_____ cubic feet
(Note: 10 cubic feet , 1 minus the shrinkage factor).

2-22. 100 cubic feet

Now, let's discuss the mixing loss. Suppose you choose to combine the one cubic foot of aggregate on the left and the one cubic foot of soil on the right.



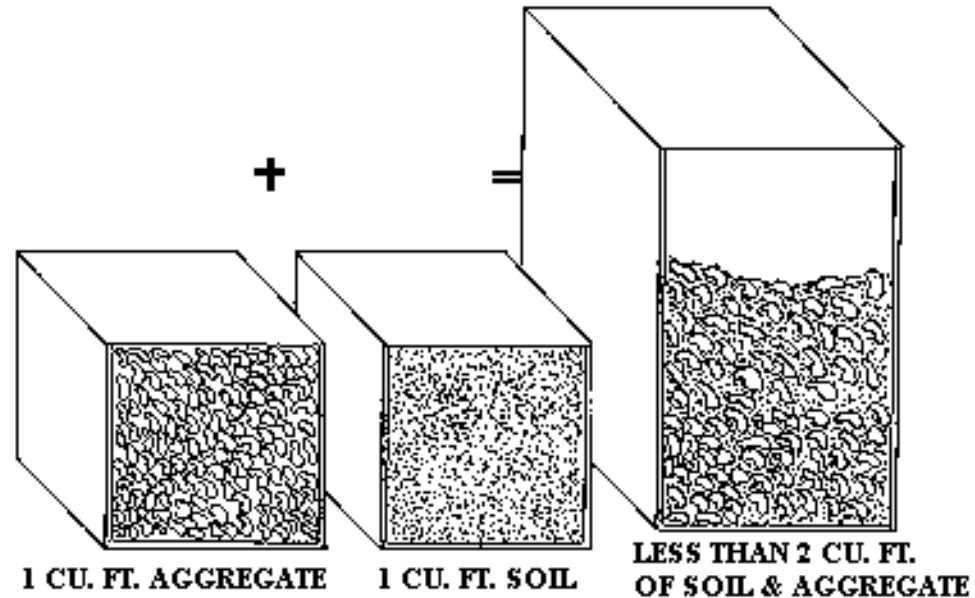
Since the aggregate particles are larger than the soil particles, they do not fit as closely together as do the soil particles. There are spaces, or voids, between the aggregate particles.

2-32. 2588.2 cubic feet

2-33. 33.6 cubic yards

2-34. 62.3 cubic yards

When you mix the soil and the aggregate, the soil particles fill in the voids between the aggregate particles. Therefore, when you mix one cubic foot of soil with one cubic foot of aggregate, you will not have two cubic feet of soil-aggregate.



This is the mixing loss - the reduction of total volume (represented by a percent value) that occurs when materials of different particle sizes are mixed. Each combination of material will have a different percentage of mixing loss and the Office of Materials and Research will determine this percentage for each combination.

Mixing loss pertains only to artificial mixtures. Natural mixtures have components that are already combined when we find them.

FILL IN THE BLANK(S):

2-27 Soil and aggregate are mixed _____ fill in the voids.

2-28 The air spaces between particles of materials are called _____.

2-29 The reduction in volume of the total material that occurs when separate components are mixed is called the _____.

2-30 The total volume of a mixture of soil and aggregate will be (greater than / the same as / less than) the total volume of separate components.

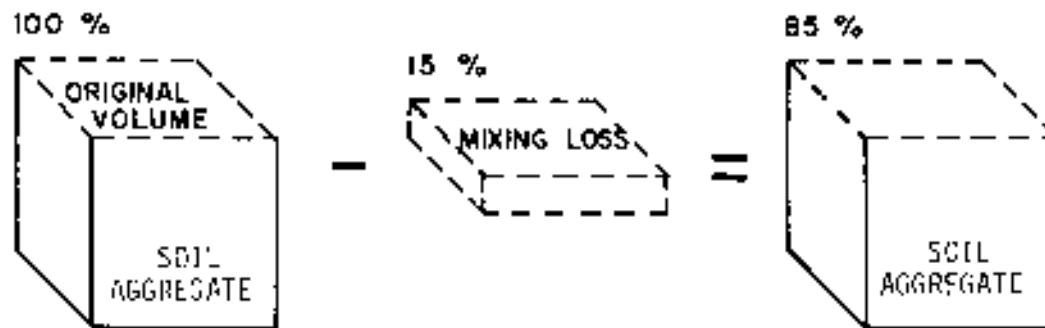
2-31 The mixing loss is expressed as a (percent / ratio / fraction).

Now that you understand the definition of mixing loss, you must now apply it to your calculations.

Let's say the total compacted volume for one linear foot of base course is 11 cubic feet and the shrinkage factor is 0.5. The loose volume needed thus far is 22.000 cubic feet ($11 \text{ cubic feet} \div 0.5 = 22.000$). Now, to correct for mixing loss if you are working with an artificial mixture:

Subtract the percentage of mixing loss from 100%.

For example, the mixing loss provided by the Laboratory is 15%. This means that when loose components are mixed together, the volume of the components is reduced by 15%.



This tells you that the total mixed volume of your material is equal to 85% of the total unmixed volume.

Divide the loose mixed volume for one linear foot by the resulting figure from the preceding step. (Change 85% to a decimal figure for division).

$22.000 / .85 = 25.882$ cubic feet of loose unmixed material.

You have now compensated for the shrinkage factor and the mixing loss, and you know that it will take 25.882 cubic feet of loose, unmixed material to end up with one linear foot of base course that is 11 cubic feet in volume.

2-24. Divide

2-25. 10 cubic feet

2-26. 20 cubic feet

The loose, uncompacted volume for one linear foot is constant, unless the dimensions or material change. Now you need to know how much loose material will be required to fill a larger section of base course - let's say 100 linear feet. (The loose material will probably be dumped by Stations.) So, multiply the total loose volume for one linear foot (25.882 cubic feet) by 100 feet (the length of the Station).

ANSWER THE QUESTION(S):

2-32 How many cubic feet will be required to fill the 100 feet of base course?

_____ cubic feet.

Since trucks will be loaded according to cubic yards, you must change the volume in loose material from cubic feet to cubic yards. 27 cubic feet equals 1 cubic yard.

Therefore, divide the total number of cubic feet by 27

$$\frac{2,588.000}{27} = 95.859 \text{ cubic yards}$$

2-41. 2303.5 cubic yards

2-42. 1535.7 cubic yards

If artificial mixes are to be mixed on the roadbed, there is one more step - you must calculate the loose volume of each component. Suppose you're mixing soil aggregate material in place. You have calculated the loose spread and found that 95.889 cubic yards are needed per Station. The proportions given to you on the project plans are 35% soil and 65% aggregate.

ANSWER THE QUESTIONS:

2-33 How many cubic yards of soil are needed? _____
(Note: 95.889 X .35)

2-34 How many cubic yards of aggregate are needed? _____
(Note: 95.889 X .65)

You have been through the entire process for calculating the volume of raw material for unstabilized base courses.

Let's briefly go through the steps again:

Find the total compacted volume for one linear foot of base course by multiplying plan width X plan depth X 1 linear foot.

To correct for shrinkage due to compaction: Divide the compacted volume by one minus the shrinkage factor. (This equals the total required loose volume before compaction.)

To correct for mixing loss if the mixture is artificial, subtract the percentage mixing loss from 100% and then divide the total loose volume by (100 - mixing loss). This equals the total required loose volume before mixing and before compaction.

To find the total required loose volume for a larger section of base course multiply the required loose volume for one linear foot by the length of the section.

To find the total required loose volume in cubic yards, divide the cubic feet of the total required loose volume by 27.

To find the required loose volume of each component of an artificial mix: Multiply the total required loose volume in yards by the percentage of the particular component.

Using the following information, answer the question(s):

Plan depth = 9 inches

Plan width = 28 feet

Mixing loss = 15%

Shrinkage factor = 0.60

Desired distance = 1,000 feet

Component proportions = 55% aggregate and 45% soil

2-30. Less than

2-31. Percent

ANSWER THE QUESTIONS:

2-35 What is the total compacted volume of one linear foot of this base course?

2-36 What is the required loose volume of one linear foot corrected for compaction?

2-37 What is the required loose volume of one linear foot corrected for compaction?

2-38 How many cubic yards total is needed.

(Remember - divide your answer by 27 to get the total required loose volume in cubic yards)

- 2-40** How many cubic yards are needed of each, aggregate and soil?
Aggregate _____
Soil _____

ANSWER THE QUESTIONS:

You are constructing a base course 9 inches thick and 20 feet wide. The construction begins at Station 25+00 and ends at 59+00. The base mixture is 60% aggregate and 40% soil. The mixing loss is 18%, and the shrinkage factor is 0.4.

2-44.

- Step 1 4.5 cubic yard
Step 2 517.5 pounds per sq. yard
Step 3 41.4 pounds of cement per sq. yard
Step 4 2.44 sq. yards per linear ft.
Step 5 101.0 pounds of cement per linear ft.

- 2-45.** 495.05 linear feet

- 2-46.** 110.6 pounds

- 2-47.** 361.7 linear feet

- 2-41** The component proportion by volume of aggregate is _____ cubic yards

- 2-42** The component proportion by volume of soil is _____ cubic yards

CALCULATING CEMENT AND LIME SPREAD

In the past sections you were calculating spread volume for loose material. In calculating cement spread, you will be calculating spread distance. Lime spread is calculated like cement spread, so to simplify the explanation, we'll use cement spread as the example.

Note: Cement manufacturers provide cement spread charts. If one of these charts is accessible to you, by all means use it. It will save time and effort on your part.

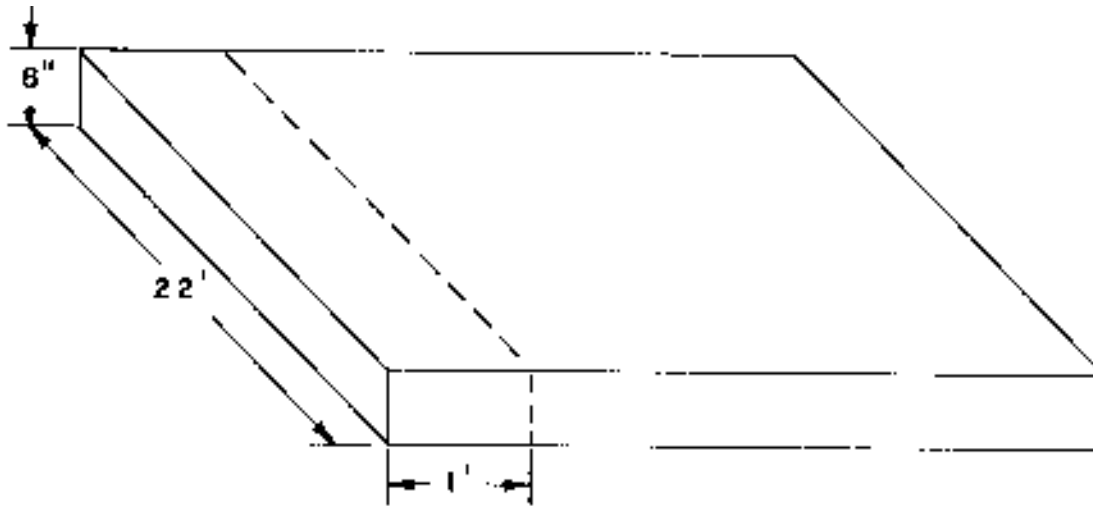
When cement arrives at the roadway, it usually will be in a large transport that will spread the cement for the base course.



You must determine how many linear feet can be spread with the weight of cement in the transport.

This is one of the approved methods of calculating spread distance.

In Step 1, first find the number of cubic feet per square yard.
(3' X 3' x depth of base course = cubic ft per square yard)



USING THE DRAWING, ANSWER THE QUESTION:

2-43 How many cubic yards are in one square yard of the previous section?

Step 2 in calculating cement spread is to determine the number of pounds of dry soil in a square yard for the plan thickness. (cubic ft. in a square yard X dry weight per cubic foot = lbs. per square yards of soil for the plan thickness)

Step 3 is to determine the number of pounds of cement required per square yard. (lbs. per square yards of soil X percent of cement weight (given by the OM&R) = pounds of cement per square yard)

Step 4 determines the number of square yards of material needed per linear foot of the roadway.(width of the roadway 9 ft. in a square yard)

- 2-35.** 21 cubic feet
- 2-36.** 52.5 cubic feet
- 2-37.** 61.76 cubic feet
- 2-38.** 61760.0 cubic feet
- 2-39.** 2287.407 cubic yards
- 2-40.** 1258.1 cubic yards
1029.3 cubic yards

Step 5 is to find the weight of cement per linear foot. (square yard per linear foot X pounds of cement per square yard = pounds of cement per linear foot)

Let's say the lab report indicated that soil cement is suitable for stabilization with 8% cement weight. The dry weight of the soil is 115 pounds per cubic foot and the base is 6 inches thick and 22 feet wide.

2-44 Using the previous steps, calculate the number of pounds of cement per linear foot.

Answers:

Step 1 _____

Step 2 _____

Step 3 _____

Step 4 _____

Step 5 _____

2-51. 310.5 pounds

2-52. 4876.2 pounds

2-53. 23205.8 pounds

Step 6 is to find out how many linear feet will be covered by a tanker, divide the number of pounds in the load by the number of pounds that will cover one foot.

(Pounds of cement per tanker ÷ pounds of cement per linear foot = the number of linear feet covered by the tanker's cement)

CALCULATE THE ANSWER:

2-45 How far will this load of cement spread?

ANSWER THE QUESTION(S):

Plan depth = 6 inches

Plan width = 23 feet

Proportion of cement = 8%

Weight of Cement in transport = 40,000 pounds

Dry weight of soil = 120 pounds per cubic foot

2-46 How many pounds of cement are needed for one linear foot of roadway?

2-47 How many linear feet can the transport spread? _____

CALCULATE THE ANSWER(S):

You are to construct a base course of stabilized soil aggregate. The component proportions are:

Soil = 37%

Aggregate = 63%

Cement = 6%

Dry Weight of Soil Aggregate Mixture = 130 pounds per cubic foot

The cement transport is loaded with 45,000 pounds. The base course is to be 6 inches deep and 20 feet wide. You are constructing between Stations 45+00 and 60+00. The mixing loss is 15% and the shrinkage factor is 0.3.

2-48 Calculate the loose spread volume for soil: _____

2-49 Calculate the loose spread volume for aggregate: _____

2-50 Calculate the spread distance for cement: _____

CALCULATING THEORETICAL WEIGHT OF CEMENT PER SQUARE YARD

If you are inspecting a stabilized base course, you will also need to be able to figure the amount of cement required for special situations such as turnouts, transitions, and crossovers.

To calculate the spread weight you must:

find the area of the turnout in square yards. (Your plan typical section will give you the needed dimensions.)

find the pounds of cement for one square yard.

find the total pounds of cement needed for the area.

Since you should be able to find the area of the turnout, let's go directly to the next step - finding the pounds of cement needed for a 10-foot by 6-foot area. The following steps are used:

Area of turn out: Multiply length by width of the area and then divide by 9 square feet per square yard.

Example: $\frac{(10.0 \text{ feet} \times 16 \text{ feet})}{9} = 6.67 \text{ square yards}$

Pounds of cement per square yard: Next multiply the dry soil density by the base thickness by the percent cement to get pounds of cement per square yard.

Example: $(115 \text{ pounds per cubic foot})(0.5\text{-foot})(.08)(9) = 41.4 \text{ pounds}$

2-43. 4.5 square yards

Total pounds of cement required: Then, multiply the pounds of cement required for one square yard by the total number of square yards to get the total pounds of cement required.

Example: 41.4 pounds X 6.67 square yards = 276.1 pounds

CALCULATE THE ANSWER(S):

- 2-51** What will be the total pounds of cement required if the plan depth is 9 inches and the percent cement is 6%? _____
- 2-52** What will be the theoretical spread weight of cement if the plan depth is 6 inches, the percentage of cement is 6%, the area of the turnout is 150.5 square yards, and the dry soil density is 120 pounds per cubic foot?
- 2-53** What will be the theoretical spread weight if the plan depth is 9 inches, the percentage cement is 9%, and the area of the turnout is 329.3 square yards, and the dry soil density is 116 pounds per cubic foot?

CALCULATING WEIGHT OF ASPHALTIC CONCRETE

If a base course is to be asphaltic concrete, you will need to be able to calculate the amount, by weight, of the asphalt mixture needed for any particular section being constructed. A general practice used in the field is to allow 110 pounds of asphalt per square yard per inch of base course.

There are four basic steps involved in this formula which we will now talk about:

Step 1 - Find the area of the particular section in square feet.

For example, the area of a section 100 feet in length and 20 feet wide would be 2,000 square feet.

Step 2 - Convert the area in square feet to square yards. Since there are 9 square feet in one square yard, divide the area by 9.

Example: $2,000 / 9 = 222.222$ square yards

Step 3 - Multiply the number of square yards by 110 pounds to get the number of pounds needed for the area. (This will be an area only one inch deep).

Example: $222.222 \text{ square yards} \times 110 \text{ pounds} = 24,444.420$ pounds for the area

Step 4 Since a base course will be more than one inch thick, multiply the number of inches of depth by the number of pounds needed for one inch.

Example: If the base course is to be 3 inches deep, then $24,444.420 \text{ pounds} \times 3 \text{ inches} = 73,333.260$ pounds total

Step 5 - Convert your answer to tons by dividing by 2000.

Example: $73,333.260 / 2000 = 36.666$ or 36.7 tons of asphaltic concrete

2-56. Raw

CALCULATE THE ANSWER:

- 2-54** A section of base course is 100 feet long, 26 feet wide, and 9 inches deep. What amount, by weight, of asphalt will be required?
- 2-55** A section of base course is 100 feet long, 24 feet wide, and 6 inches deep. What amount, by weight, of asphalt will be required?

PREMIXING OF BASE COURSE MATERIALS

We said at the beginning of Chapter 2 that the Chapter would cover procedures that must take place before base course construction could begin. This section of Chapter 2, 'Premixing,' deals with a procedure which does take place before construction if the contractor chooses one of the particular methods of premixing. He may however, choose the in-place mixing method, which is done on the subgrade of the roadbed and is part of the actual construction.

Premixing of base course materials is done away from the actual job site. The materials are ready for actual placement and spreading when they are delivered. There are three methods of premixing which we will briefly discuss in this section: the mixing table, the pugmill plant, and the asphaltic concrete plant. Before we get into these methods, let's discuss why mixing is important.

Mixing is important for the following reasons:

- Mixing helps to obtain a uniform particle mixture.
- Mixing helps to make the mixture stable.
- Mixing helps to prevent failures.
- Mixing helps the roadway materials obtain the required load-bearing capacity.

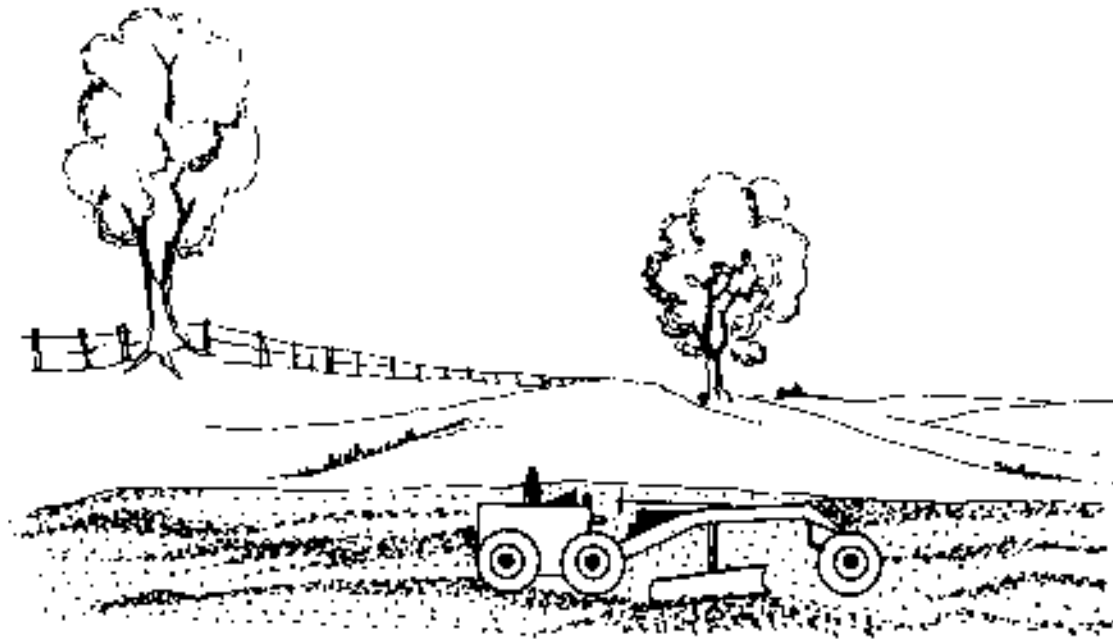
The first method of premixing materials is the mixing table, which is used only to mix components of raw materials. The mixing table is a flat area that is usually located near the roadway that the contractor has cleared of trees and debris and has smoothed off. The size of the cleared area depends on the amount of material to be mixed.

2-48. 345.5 cubic yards

2-49. 588.2 cubic yards

2-50. 576.9 linear feet

2-65. By mixing components on a working surface of the same material

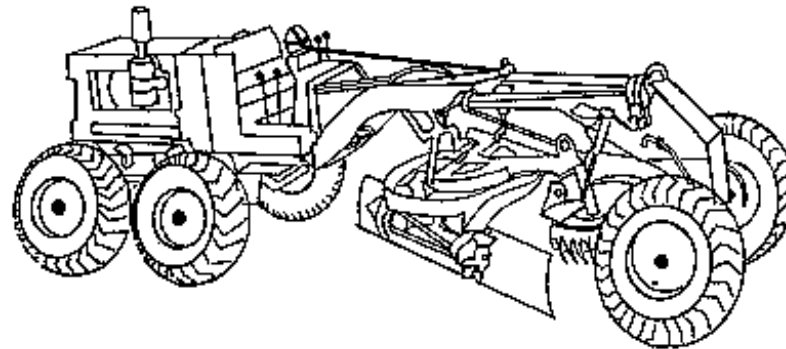


2-66. The aggregate

FILL IN THE BLANK(S):

2-56 A mixing table is used to mix components of _____ materials.

Any one of several machines may be used to mix components on a mixing table. This sketch shows the motor grader that is the piece of equipment most commonly used.



CIRCLE TRUE OR FALSE

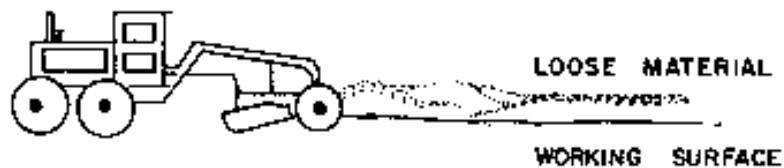
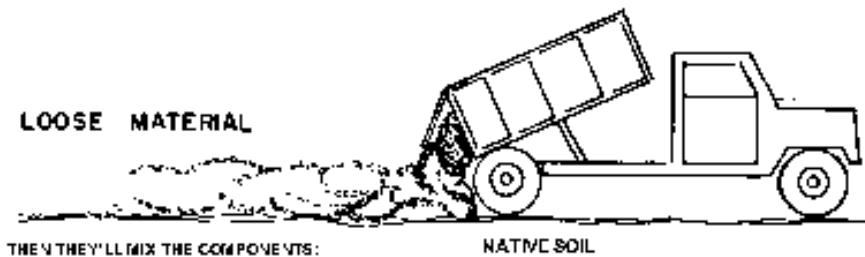
- 2-57 True False Materials do not have to be mixed to obtain the required load-bearing capacity.
- 2-58 True False A 6-acre mixing table is needed to mix any quantity of material.
- 2-59 True False A mixing table is usually located near the roadway.
- 2-60 True False We use a mixing table to mix the stabilized aggregates.
- 2-61 True False The contractor chooses the machine to be used.
- 2-62 True False The contractor is responsible for constructing the mixing table.
- 2-63 True False The amount of material to be mixed determines the size of the mixing table.
- 2-64 True False It is not necessary to clear debris from a mixing table.

2-54. 143 tons

After the area is cleared, contractors will haul in some of the same material that they'll be mixing. They will spread this material over the mixing table in a layer.

2-55. 88 tons

This first layer will serve as a cover or working surface over the native soil during mixing.



The motor grader operator has to exercise care not to penetrate the working surface in order to prevent contamination of base material by the native soil.

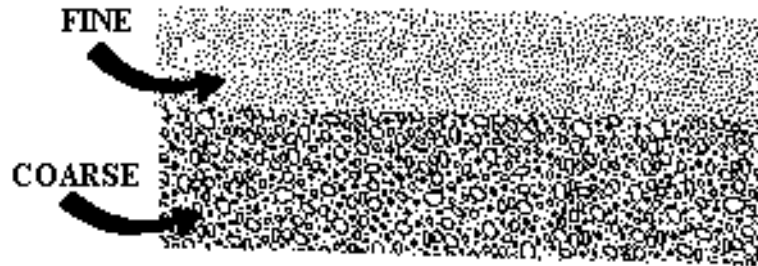
ANSWER THE QUESTION:

2-65 How do contractors make sure that no native soil is mixed in?

After the area has been cleared and the working surface compacted, the correct amount of each component of the material is hauled to the mixing table. Each component is sampled, tested, and approved by the lab before being hauled.

These components are spread evenly in depths of 6 to 12 inches. The fine components are spread on top of the coarse components.

2-68. Raw
Raw
Stabilized



ANSWER THE QUESTION:

2-66 If we're mixing soil aggregate, which component do we spread first?

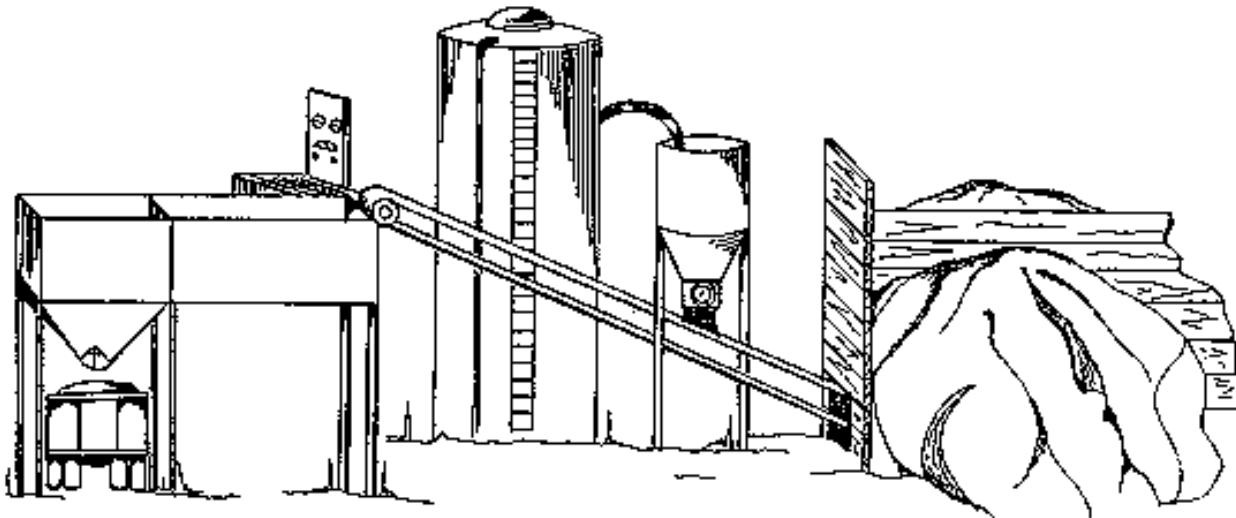
After the components are blended and mixed uniformly, the material is hauled to the roadway, which is the topic of the next section of Chapter 2.

2-67 Number the steps to put them in order of occurrence. You are using a mixing table to blend the material you're using.

- _____ A. You make a working surface out of the same material you'll be mixing.
- _____ B. You proportion the accepted components.
- _____ C. You choose a flat area near the construction site.
- _____ D. You haul and spread the fine components.
- _____ E. You haul and spread the coarse components.
- _____ F. You clear the area of trees and debris.
- _____ G. You mix the components uniformly.
- _____ H. You haul the mixture to the roadway.

Materials used to construct the base course must be inspected both before and after mixing in order to make sure they meet specifications. Non-specification material could cause failures in the base course.

Another method of premixing is through the use of a pugmill plant. This kind of plant is not as widely used today in Georgia as it has been in the past; however, you should be familiar with some of the basic characteristics of the pugmill plant.



2-57. False

2-58. False

2-59. True

2-60. False

2-61. True

2-62. True

2-63. True

2-64. False

The previous sketch is a typical pugmill plant that mixes components of base course materials automatically. The materials can be either raw or stabilized materials.

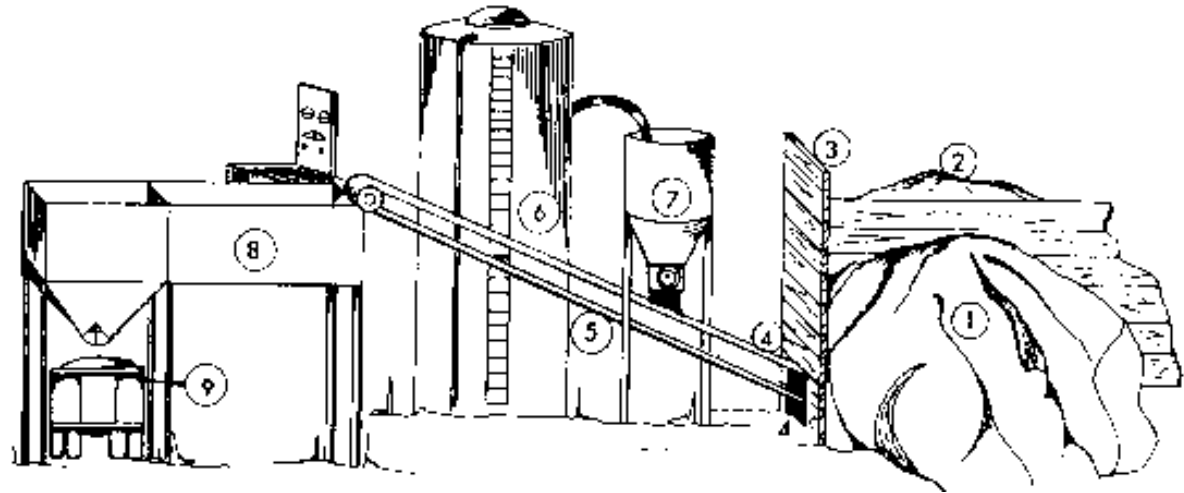
FILL IN THE BLANK(S):

2-68 Mixing tables are used to mix _____ materials, and pugmill plants can be used to mix _____ and _____ materials.

The parts of the pugmill plant have been numbered and explained below. This particular plant is being used to mix stabilized soil aggregate.

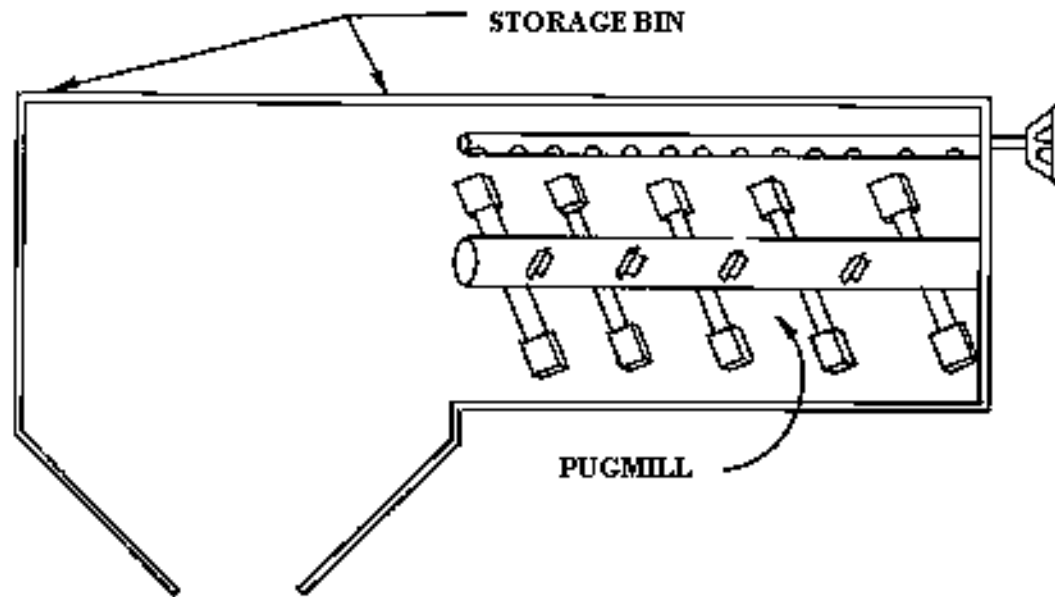
- 2-69. A. 5
B. 3
C. 8
D. 1 and 2
E. 6
F. 9
G. 4
H. 7

- 2-70. Shafts and paddles
spray bar



- 1) and 2) The aggregate and soil are stockpiled.
- 3) Bulkheads separate the two stockpiles.
- 4) The front bulkhead contains gates by which material is moved to the conveyor.
- 5) The main conveyor carries the aggregate and soil to the pugmill.
- 6) The cement silo stores the cement.
- 7) The cement hopper deposits cement on to the conveyor.
- 8) The pugmill mixes and pulverizes the components.
- 9) The haul truck is loaded with the stabilized soil aggregate mixture for delivery.

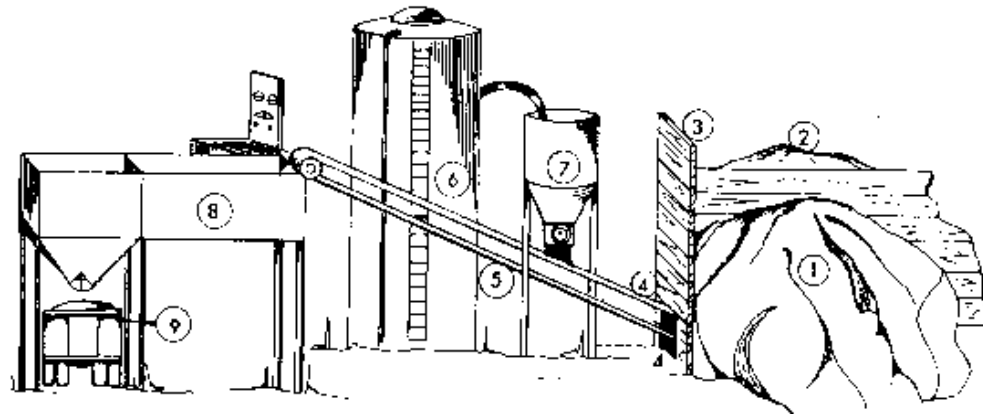
Let's take a closer look at the pugmill. If you could see through one it would look like this:



There are two important items in the pugmill. The first are the shafts of paddles that do the actual pulverizing and mixing, and the second is the spray bar that is used to add moisture to the pugmilled mixture. The valve on the right regulates the amount of water sprayed through each bar.

After mixing, the mixture moves into the pugmill storage bin. The discharge gates on the storage bin are closed until the bin is filled. Then the gates open to release the mixture into a haul truck.

2-69 Match the parts of the pugmill plant with the appropriate description.



2-73. Area Engineer

- _____ A. carries aggregates to the pugmill
- _____ B. separates stockpiles
- _____ C. mixes and pulverizes the components
- _____ D. stockpiles of aggregates
- _____ E. stores cement
- _____ F. delivers mixture to roadway
- _____ G. gates by which material is moved to conveyor
- _____ H. deposits cement onto the conveyor

ANSWER THE QUESTION:

2-70 Two important parts of the actual pugmill are the _____ and the _____

SAMPLING BASE COURSE MATERIALS

If base course materials have been premixed, the mixtures should have already been sampled and tested by the Office of Materials and Research before delivery. However, if they have not or are individually shipped they may need to be still sampled and tested to determine whether or not they meet specification requirements.

The Office of Materials and Research's Testing Management Branch is responsible for the sampling and testing of the materials incorporated on the job. Each time they sample a component, a DOT Form 170 Sample Card, illustrated below, is filled out and submitted with the sample. When the lab tests the sample, they fill out a report form giving the results of all tests run on that sample and submit it to the Area Engineer for review.

DOT 170 SAMPLE CARD FOR ALL MATERIALS	
Sample Type: Control	Independent Assurance
Project No. _____	County _____
Material _____	Size or Type _____
Date Sampled _____	Sample No. _____
Sampled From _____	Sample Represents _____
Producer or Property Owner _____	
Location _____	
Contractor _____	
Examined For _____	
Used In _____	Submitted By _____
Remarks: _____	

FILL IN THE BLANK(S):

- 2-71 Materials delivered to the job site are individually _____ and _____ in order to determine if they meet _____.
- 2-72 Each sample submitted by the _____ has a _____ sample card with it.

2-74.

STATION	STATION	LINEAR FT.
12+80	15+00	220

LBS. CEMENT	SPREAD RATE	TRUCK NO.
28819	08	5

SEAL NO.	DATE	INITIALS
97975, 97976, 97977, 97978, 97979, 97980	5/13/77	W.L.J.

2-75. False

2-76. True

2-77. False

2-73 The results of the tests are reported to the _____.

CEMENT OR LIME

Cement and lime are brought to the roadway in a transport. The rear view of this transport shows the distributor pipe. The use of "blow tubes" as shown in the photograph below is not permitted by the specifications. The lime or cement must be spread with a mechanical spreader.



The cement or lime must be carried in a sealed transport. The seals are put on when the transport is loaded, and they are broken only after the transport arrives at the roadway. You are required to keep these seals as part of your project records, you should also be present when the seals are broken. You must reject any shipment having broken or missing seals!

[illegible]

2-72.
Office of Materials and Research
(test Management Branch)
DOT 170

[illegible]

2-83. c. Divide the compacted volume by one minus the shrinkage factor.

2-84. a. Percent

2-85. b. 94 pounds

2-86. a. Raw materials

2-87. a. Raw materials
b. Stabilized soils and aggregates

2-88. c. One

2-89. c. Shipper's Invoice

Document the inclusive Stations first. Then record the linear feet. Next, record the pounds of cement, actual spread rate and the truck number. Then record the seal numbers (indicated on the Certificates of Delivery) and the lab number. The last two columns are for the date and your initials.

2-74 Fill in the following information on the previous sample document:

A transport loaded with cement arrives at the roadway on May 13, 1977. The seals are numbered 97975, 97976, 97977, 97978, 97979 and 97980. The cement spread covers Stations 12+80 to 15+00 in zone 3. 28,819 pounds of cement were delivered and spread. 8% cement is used for stabilization. Transport No. 5 brought in the cement.

Cement and lime are usually pretested and approved; however, the OM & R will be required to take one verification sample per project - the sample representing only one tanker. The sample should be taken from a pile on the roadway And not the tube coming from the back of the truck.

CIRCLE TRUE OR FALSE

2-75 True False Cement or lime is never sampled at the roadway.

2-76 True False One sample of cement represents no more than one tanker.

2-77 True False Lime sample are taken from the flow at the back of the transport.

The following is a list of "don't's" concerning cement for base courses:

Different brands of cement must not be mixed together.
Different types of the same brand must not be mixed together.
Different brands, or different types of the same brand, must not be used alternately.
Cement salvaged from discarded bags must not be used.

ASPHALTIC CONCRETE

Asphaltic concrete is delivered to the job site in haul trucks. The mixture is hot - it should be no cooler than 20°F below the minimum allowable temperature of the mixture when discharged from the mixer at the plant. Asphaltic concrete base material is sampled and tested in accordance with the Sampling, Testing, and Inspection Manual.

FILL IN THE BLANK(S):

2-78 The temperature of the mixture must not be lower than _____.

CHAPTER 2 REVIEW

CIRCLE THE CORRECT ANSWER(S):

- 2-79** What effect does a high spot in the subgrade have on the base course?
- a. The depth of the base course is increased.
 - b. The depth of the base course is decreased.
 - c. The depth of the base course is not effected.
- 2-80** Large deficient areas in the roadbed:
- a. should be reworked
 - b. should be removed and reworked
- 2-81** The shrinkage factor is:
- a. the percent compaction to be reached by a lift of material.
 - b. the process which causes small and large particles of material to fit closely together.
 - c. the value needed to calculate the volume of loose material required to fill a compacted area of certain dimensions.
- 2-82** What is the total compacted volume for one linear foot of base course with a depth of 8 inches and a width of 24 feet?
- a. 15 cubic feet
 - b. 15.504 cubic feet
 - c. 15.984 cubic feet
 - d. 15.489 cubic feet

- 2-83** To find the loose material needed for a particular volume:
- multiply the shrinkage factor volume
 - divide the compaction factor by the by the volume.
 - divide the compacted volume by one minus the shrinkage factor.
- 2-84** Mixing loss is expressed as a:
- percent
 - ratio
 - fraction
 - decimal
- 2-85** One cubic foot of cement weighs:
- 90 pounds
 - 94 pounds
 - 98 pounds
 - 100 pounds
- 2-86** A mixing table is used to mix components of:
- raw materials
 - stabilized soils and aggregates
 - asphaltic concrete mixtures
- 2-87** A pugmill plant can be used to mix components of:
- raw materials
 - stabilized soils and aggregates
 - asphaltic concrete mixtures
- 2-88** How many Sample Cards are filled out when submitting a sample?
- two
 - four
 - three
 - one
- 2-89** What form should you collect when cement is delivered?
- Project Sampling Plan
 - Certificate of Delivery
 - Shipper's Invoice
 - DOT Form 170 Sample Card

CALCULATE THE ANSWER(S):

2-90 How many cubic yards of loose uncompacted soil and aggregate are needed if:

plan depth = 9 inches

plan width = 26 feet

shrinkage factor = 0.4

mixing loss = 18%

spread distance = 1,500 feet

component proportions - soil = 42% and aggregate = 58%

Answer:

soil _____ aggregate _____

2-91 Calculate the spread distance if:

plan depth = 8 inches

plan width = 24 feet

proportion of cement = 8%

weight of cement in transport = 50,000 pounds

dry density of soil = 111 pounds per cubic foot

Answer _____

2-92 Determine the theoretical spread weight of cement if:

plan depth = 8 inches

proportion of cement = 8%

area of the turnout = 180.5 square feet

dry density of soil = 111 pounds per cubic foot

Answer _____

2-93 Determine the amount, by weight, of asphaltic concrete needed for a section of base course if:

plan depth = 5 inches

plan width = 25 feet

length of the section = 100 feet

Answer _____

2-78. 25°F below the minimum allowable temperature of the mixture when discharged from the plant

2-79. b. The depth of the base course is decreased.

2-80. b. Should be removed and reworked.

2-81. c. The value needed to calculate the volume of loose material required to fill a compacted area of certain dimensions.

2-82. c. 15.984 cubic feet

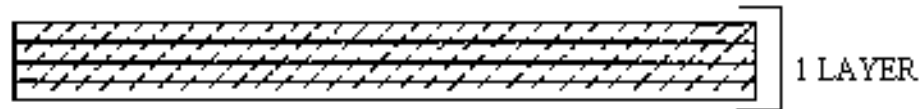
CHAPTER 3: BASE COURSE CONSTRUCTION

Now that materials have been hauled to the roadway, the construction process can begin. This Chapter covers in detail the construction steps that were briefly mentioned in Chapter 1 - mixing spreading; compacting; and finishing. These steps will be applied to the three main types of base courses - raw aggregate, stabilized soil and aggregate, and asphaltic concrete.

You learned in Chapter 1 that a base course is constructed in layers, or lifts. The number of lifts used to construct a base course depends on the type of material being used. For example, stabilized base courses are often constructed in one layer, while other base courses are multi-layered.

It is important to remember that prior to any base course being placed the subgrade is to be checked to make sure it is on grade and per plans. This information is to be recorded in a field book. As each lift is constructed, a certain amount of sampling and testing must be done in order to assure a stable and uniform base course. Material that is placed and processed in one lift requires only one passing sample and test for acceptance. (See Georgia Sampling, Testing, and Inspection Manual for frequency).

MONOLITHIC - ONE PASSING SAMPLE & TEST PER ZONE



In multi-layered construction, where lifts are thick enough to be constructed in separate operations, each lift will be sampled and tested separately.

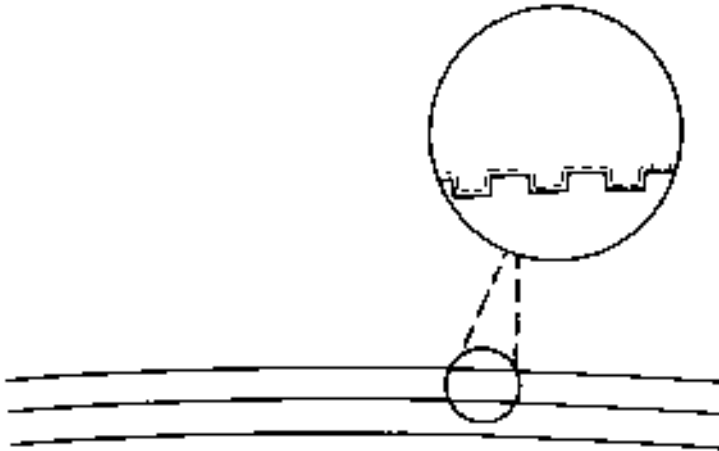
MULTI-LAYERED - TWO PASSING SAMPLES AND TESTS PER ZONE



FILL IN THE BLANK(S):

- 3-1 Material that is constructed in one operation requires _____ passing sample(s) per zone.
- 3-2 Material constructed in more than one layer, or lift, requires _____ passing sample(s) per zone.
- 3-3 The construction of lifts varies according to the _____ being used.
-

As each lift is being placed and compacted, it is important to make sure that the top surface of the lift is fairly irregular or rough before placing the next lift. (For all base courses except asphaltic concrete base course). This irregular surface will provide the necessary friction to bond that lift to the lift placed on top of it. Use one course construction only on soil cement.



If the surface of one lift is too smooth, the lift placed on top of it will slide, thus forming a plane of slippage. This is called shifting, and it causes a base course to be unstable and to be off crown. This slippage could cause cracks (or breakage) in one of the lifts and this could cause a failure in the pavement.

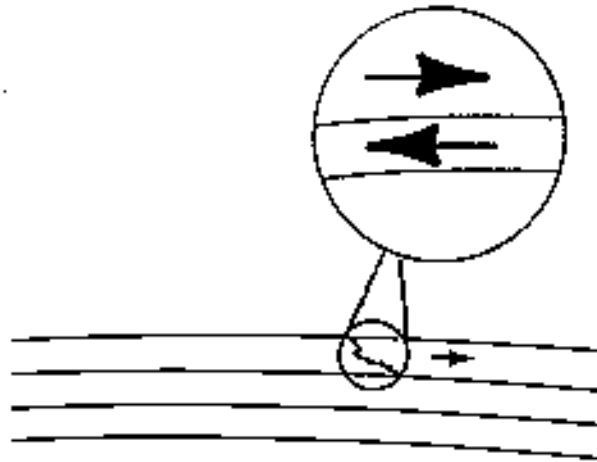
2-90 soil 924.7 cubic yards
aggregate 1277.1 cubic yards

2-91 349.7 linear feet

2-92 1073.9 pounds

2-93 76.4 tons

3-9 Fine
 Coarse
 Motor patrol



FILL IN THE BLANK(S):

- 3-4 The top surface of a lift should be _____ to provide friction for the lifts to bond together.
- 3-5 If the surface of a lift is too smooth, the lift on top of it will _____.
- 3-6 The sliding of a lift could cause _____ which would cause _____ in the pavement.

The Standard Specifications do not specify a minimum length of the subgrade to be in final condition to receive the base course. However, it is desirable that enough roadbed be finished for one-day's run in order to give you time to inspect it. This will also give the contractor enough time to drop back and make necessary corrections or repairs without holding up the construction operation. On the other hand, having too much of the subgrade in final condition would allow traffic to damage it before the base course is placed upon it.

Before construction of any type of base course begins, be sure that you are familiar with the layout and grade control as shown in the project plans and specifications. Ask yourself the following questions:

- Were lab reports, soil surveys, etc., reviewed and do they correlate with job conditions?
- Has the subgrade been stringlined and the results recorded.
- Has the subgrade been inspected and corrected for any deficiencies?
- Is all of the construction equipment properly adjusted and in good working condition?

RAW, UNTREATED BASE COURSES

Depending upon the method used for mixing untreated aggregates, the material will be placed on the subgrade in one of two ways:

If the material has been premixed prior to placement, it will be hauled in from the mixing table or pugmill and then spread.

If the material is not premixed, the components will be hauled in, dumped at regular intervals on the subgrade, spread, windrowed, and spread again.

- 3-1 One
- 3-2 More than one
- 3-3 Material

FILL IN THE BLANK:

3-7 Material hauled in for the base course may be mixed on the subgrade, or it may be _____.

A mechanical spreader usually spreads material that comes from a mixing table or pugmill. A mechanical spreader is wheel mounted and is usually pushed by a bulldozer. The spreader distributes the material in a uniform layer.

The particular part of the spreader that causes the material to be spread uniformly is called the strike-off bar. The height of the strike-off bar can be adjusted so that it will yield the correct loose thickness of material during spreading. Therefore, since the loose material is to be compacted to a specific depth, the strike-off bar is set at a height that is greater than the required depth of the compacted base course.

FILL IN THE BLANK:

3-8 The strike-off bar causes material in the spreader to be spread uniformly to the proper loose _____.

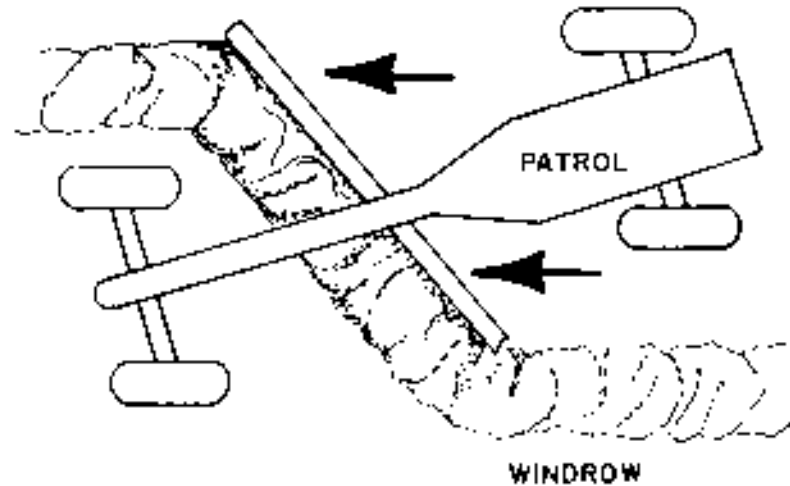
If material is to be mixed on the roadway, the components are usually dumped at regular intervals. Dumping in large piles should not be permitted. This results in segregation, non-uniform densities, or hard spots developing at the bottom of the pile.

Coarse components are dumped and spread first, and then the fine components are dumped and spread over the coarse components. The motor grader then mixes the material by windrowing it toward one side of the road and then toward the other.

3-17 Might not

3-18 must

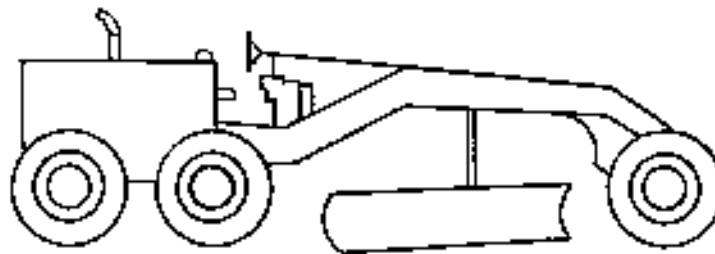
3-19 must



FILL IN THE BLANK(S):

3-9 _____ components are spread over _____ components, and are then mixed by the _____.

The process will be repeated until the mixture is well blended. The part of the motor grader that does the mixing is the blade.



If the blade is not in good condition it will be hard to get a well-blended, uniform mixture. The contractor will decide whether to replace the blade. If he can get a good mix by using a worn blade, that's fine. However, you can (and should) suggest that the blade be replaced if the mix is not well blended.

After the mixture is well blended, the motor grader will spread the windrowed material over the surface of the sub-grade. No matter which method the contractor uses to spread the base course material, you must make sure that it is spread uniformly.

FILL IN THE BLANK(S):

- 3-10 Material hauled in for an untreated aggregate base course may either be _____ or mixed-_____.
3-11 A haul truck, or a haul truck and a _____, may be used to spread premixed material.
3-12 The motor grader mixes the materials by _____ them from one side of the road to the other.
3-13 No matter which method the contractor uses to spread the base course material, you must make sure that it is spread _____.

3-7 Premixed
3-8 Thickness

CIRCLE THE CORRECT ANSWER(S):

- 3-14 The strike-off bar is set at a height that is (greater / less) than the required depth of the compacted base course.
3-15 The strike-off bar should be adjusted so that when the loose material is compacted, the (width / depth) of the base course is within tolerance.
3-16 If material is to be mixed-in-place, the motor grader will spread the (fine / coarse) material over the (fine / coarse) material.

3-20 Should have filled in the form with:
Sample - No. 1-3A
Remarks - Resample for No. 1-3A.
Contractor sweetened with 200 pounds per square yard of M10 screenings

The untreated aggregate material that has been mixed must meet certain criteria before compaction. The requirements concern the:

mixture uniformity
gradation
moisture content
shape of the lifts

As the inspector you have the responsibility of knowing these requirements and seeing that they are met. Let's examine each of the items mentioned above.

THE MIXTURE

Each lift must be checked before compaction to make sure that it is mixed uniformly. You should look for any:
streaks of color
streaks of moisture
streaks of coarse or fine particles

A uniform mixture should have none of these things! Inform the contractor if the mixture is not uniform.

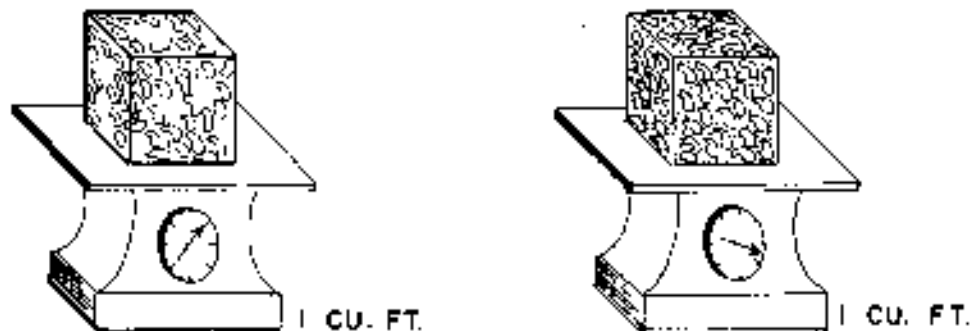
CIRCLE THE CORRECT ANSWER:

- 3-17 A mixture that contains streaks of color, moisture, or fine particles (will / might not) obtain maximum density during compaction.
- 3-18 Untreated aggregate material (must/must not) meet certain criteria.
- 3-19 Each lift (must/must not) be inspected before compaction.

GRADATION

In addition to having a uniform mixture, each lift of loose base material should be graded properly. Gradation is the percentage by weight of different-sized particles in a mixture.

Proper gradation helps a material obtain strength. The strength of a raw aggregate depends partially on the unit weight of the total material. A properly graded material has a higher unit weight after compaction than one that is not properly graded. Look at these two compacted materials. Each material occupies one cubic foot.



The material on the left does not have proper gradation. There are many air voids between the large particles. One cubic foot of this material would weigh less than the same amount of a properly graded material.

The material on the right has proper gradation. It has the same percentage of large particles as the material on the left but the air voids are filled by fine material. One cubic foot of this material would weigh more than the material on the left.

If the materials were mixed-in-place, the total material must be tested by the O M & R ,after mixing, to see if the gradation is within tolerance. If gradation tolerance is not met, then recheck samples are taken.

If the recheck samples fail, the material will be remixed, or, if the material being used is pit-run (natural), the mixture will require "sweetening" (the addition of necessary amounts of the deficient component to the base course to bring it within specifications).

Sweetening, resampling, and retesting must continue until the base course material meets specifications, or until new material that meets gradation requirements is brought in. This is the only way to be sure that the material is graded properly.

Remember, whenever a sample is taken by the lab for testing, whether it is the original sample or a resample, a DOT 170 sample card will be included. If it is a resample, the form is filled out as usual except:

The resample is cross-referenced to the original sample.
It should tell what corrective action has been taken in the space reserved for "Remarks."

- 3-10 Premixed
In-place
- 3-11 mechanical spreader ox
- 3-12 Windrowing
- 3-13 Uniformly
- 3-14 Greater
- 3-15 Depth
- 3-16 Fine

- 3-20** Using the following information, fill out the appropriate lines on the form:
The original sample was identified as "No. 1 - 3."
The sample failed.
The contractor sweetened the area represented by this sample with
200 pounds per square yard of M10 screenings.

DOT 170		SAMPLE CARD FOR ALL MATERIALS	
Sample Type: Control		Independent Assurance	
Project No. _____		County _____	
Material _____		Size or Type _____	
Date Sampled _____		Sample No. _____	
Sampled From _____		Sample Represents _____	
Producer or Property Owner _____			
Location _____			
Contractor _____			
Examined For _____			
Used In _____		Submitted By _____	
Remarks: _____			

Each time a roadway interval is sampled, or corrected and resampled, O M & R personnel document the sample information in a sample log book:

SAMPLE NO.	STA. NO.	LIFT NO.	DATE	RESULTS	CROSS REFERENCE	REMARKS	INI.
3-1	3	1	4/10/00	Failed on No. 4 Screen	3-1A	see page 68	W.L.J.
3-1A	3	1	4/10/00	Passed	3-1		W.L.J.

3-21 Document the following information on the sample form that follows:

A sample is taken at Station 3, Lift 1, on August 10, 1997.

Sand-clay-gravel is being sampled.

It fails on the #4 screen.

The area is sweetened with 200 pounds per square yard of M10 screenings.

The area is resampled on August 12, 1997.

The resample fails to conform to specifications.

100 pounds per square yard more of M10 screenings are added.

The area is resampled again on August 14, 1997.

This sample passes.

SAMPLE NO.	STA. NO.	LIFT NO.	DATE	RESULTS	CROSS REFERENCE	REMARKS	INI.

Remarks found on Page 70 - Sample No. 3-1: Added 200 pounds per square yard of M10 screenings and resampled. Sample No. 3-1A: resample for sample 3-1 - Added 100 pounds per square yard of M10 screenings and resampled again. Sample No. 3-1B: resample for sample 3-1A - passed.

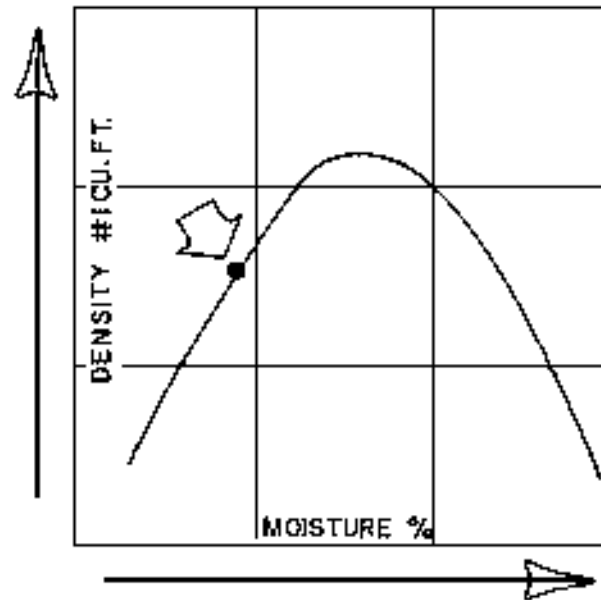
MOISTURE CONTENT

In addition to having a uniform mixture and proper gradation, each lift should have a moisture content that is uniform and near optimum. The Standard Specifications state that untreated aggregate based course materials should be brought to the moisture content required for compaction to the required density. The recommended moisture content and theoretical maximum density for raw aggregate materials will be provided by the District Laboratory.

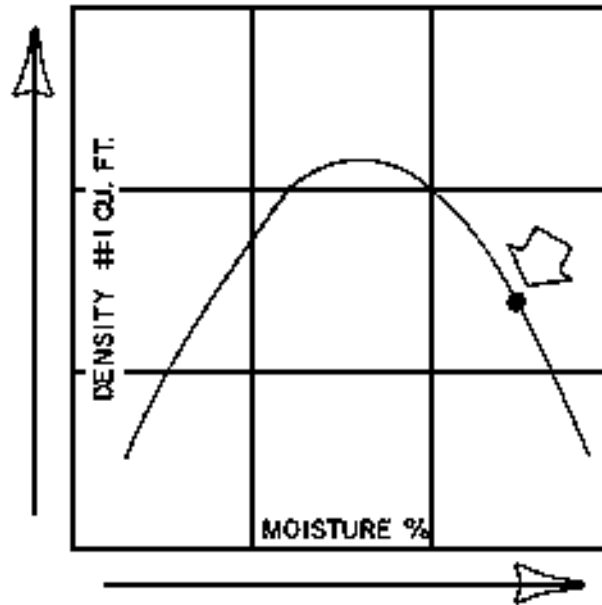
If soil aggregate material is compacted at its optimum moisture content it is easier to obtain the required density during compaction.

The graphs, following, explain why it is important for a material to have the proper moisture content. These are moisture-density curves. The peak of the curve represents theoretical maximum laboratory density at optimum moisture after compaction. Points on the dry side of the curve represent moisture content approaching optimum. Points on the wet side of the curve represent moisture content that has exceeded optimum.

In the following case, the moisture content is not great enough. This material will not reach the maximum density for a given compactive effort.



In this next case too much water has been added. The moisture content is too high - it has gone too far beyond optimum. The material will not reach maximum density for a given compactive effort.



When the proper amount of water has been added to the material it will reach maximum density for a given compactive effort.

Moisture and density are closely related because:

Moisture lubricates soil particles, causing them to slide over each other and form a denser mass.

At the time of compaction, the density of a material increases for a given compactive effort with every increase in moisture content until the optimum moisture content is reached.

If the moisture content is increased beyond optimum at the time of compaction, the soil particles will be displaced by water. This will cause density to decrease, since water weighs less than the materials.

FILL IN THE BLANK(S):

3-22 You are more likely to get the required density if you compact an untreated material at or near optimum _____.

3-21

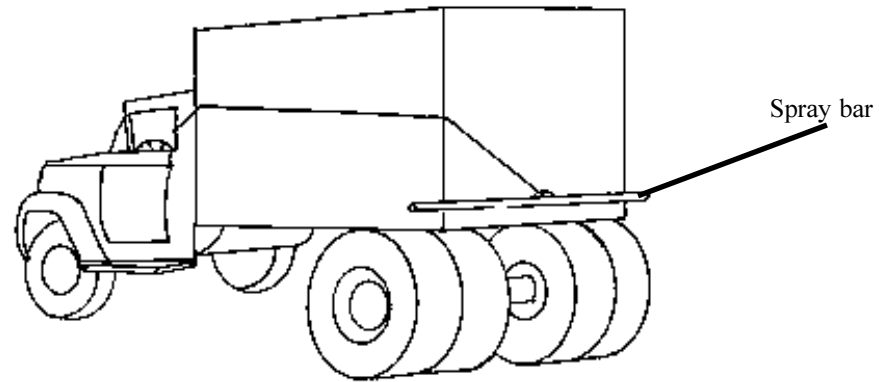
SAMPLE NO.	STA. NO.	LIFT NO.
3-1	3	1
3-1A	3	1
3-1B	3	1

DATE	RESULTS	CROSS REFERENCE
8/10/77	Failed on No. 4 Screen	3-1A & 3-18
8/12/77	Failed on No. 4 Screen	3-1
8/14/77	Passed	3-1A & 3-1

REMARKS	INI.
See Page 70	W.L.J.
See Page 70	W.L.J.
See Page 70	W.L.J.

A water truck is used to add moisture to an untreated material. The water must be spread evenly and uniformly over the surface of the lift. To spread the water uniformly the truck must travel at a constant rate of speed. If for some reason the truck stops while moistening the lift, they need to make sure the water is turned off.

All of the holes in the spray bar at the back of the water truck must be in good operating condition and unclogged. If the spray bar becomes clogged or too much water is spewing from one hole, stop the truck and notify the contractor.



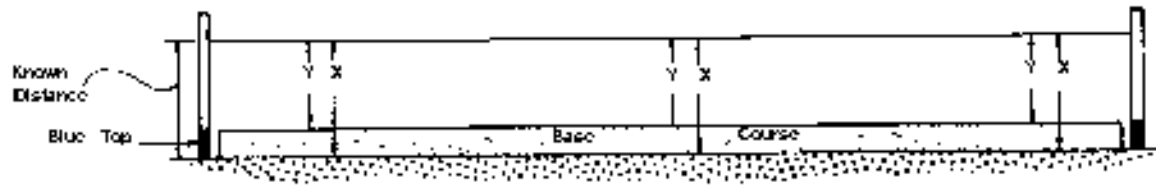
Moisture tests should be run several times a day, especially on hot days. When moisture is needed it can be added to raw base course material at any time before or during compaction.

SHAPING THE LIFT

In addition to being mixed uniformly, having the proper gradation and correct moisture content, each lift must be spread uniformly. The depth should be fairly even with no obvious high or low spots. A relatively uniform depth is easy to obtain if the material is spread with a mechanical spreader. If the material is truck-dumped, the motor grader will be used to level off the loose spread.

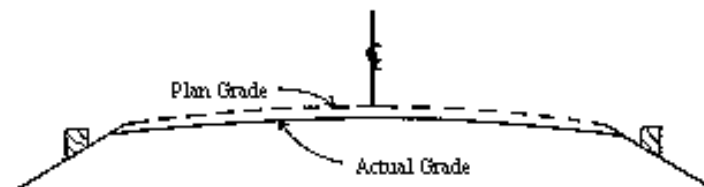
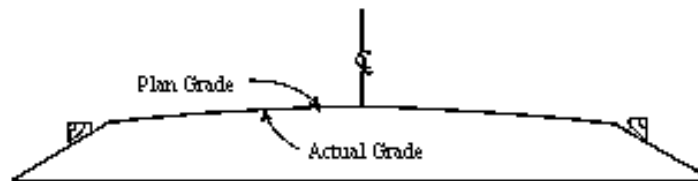
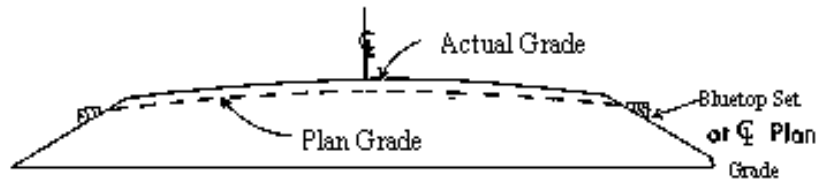
Each lift should be shaped roughly to plan grade. This will make it easier to control the grade in the top lift. The material should be spread thick enough to bring the compacted surface slightly above final grade so that fine grading will be a trimming operation rather than a filling operation.

A means of checking for uniform depth is by using a stringline stretched between points of known elevation.



CIRCLE THE CORRECT ANSWER:

3-23 Which of the following lifts (the top / the middle / the bottom) is spread roughly to plan grade?
COMPACTION OF A RAW, UNTREATED AGGREGATE BASE COURSE



3-22 Moisture content

After a lift of base course is spread, it must be compacted so it will withstand the effects of traffic. Compaction increases the stability of a material. Many types of compaction equipment can be used to obtain the required density. The contractor may use any approved machinery that is in good condition.

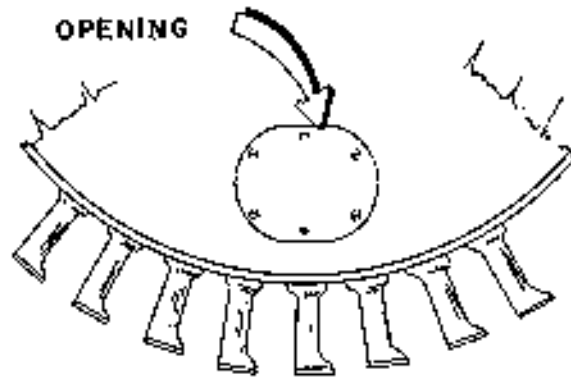
One of the most effective pieces of compaction equipment used on materials spread in thick lifts and materials with a high binder (clay) content is the sheepfoot roller.



The sheepfoot roller is a hollow, closed drum with "feet" attached to the rolling surface. The feet on the sheepfoot may be of any shape and length, depending on the type of material being compacted and the thickness of the lift. All of the feet on the roller must be of the same type. None should be missing or excessively worn.

3-25 Is not

There is an opening in one end of the drum.



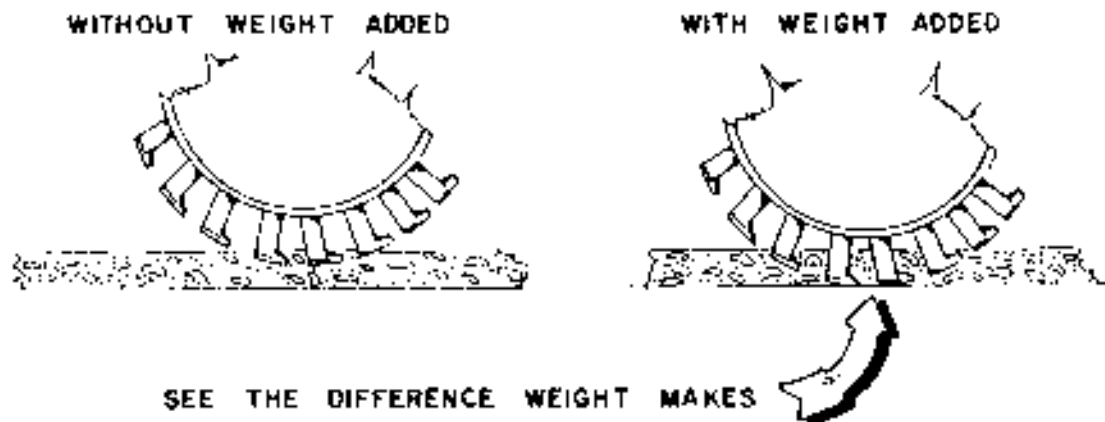
The contractor uses this opening to put water and sometimes sand inside the drum. This makes the roller heavier so it can compact with greater force.

3-23 The middle

CIRCLE THE CORRECT ANSWER:

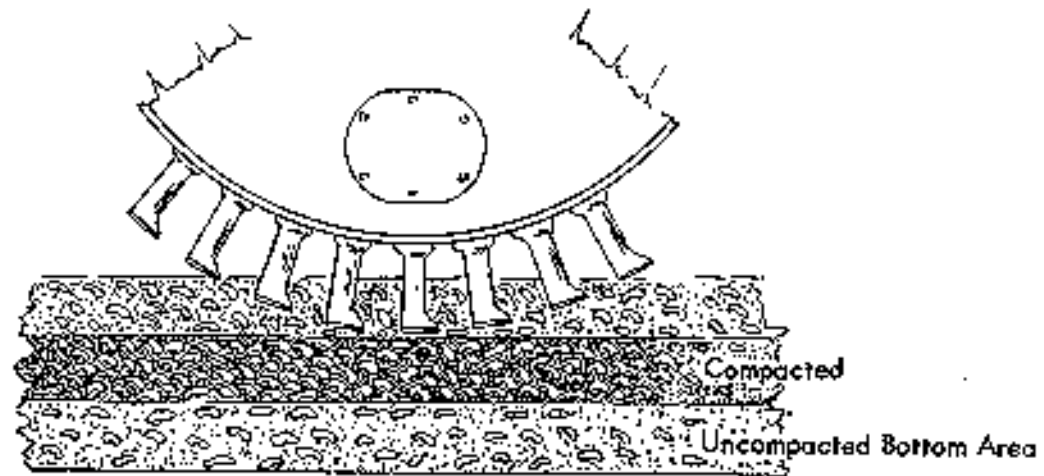
3-24 The weight of the sheepfoot roller (can/cannot) be adjusted.

When the weight of the roller is increased, its compactive effort is increased with the same number of passes.



The feet should be long enough to penetrate to the bottom of the lift without the drum riding on the lift. As compaction is achieved, the roller will begin to "walk out." When properly compacted, a lift will have uniform density throughout its full depth.

Look at this sheepfoot roller. It is not penetrating to the bottom of the lift.



This action results in "bridging." Bridging occurs when the equipment compacts only the top part of a lift, leaving the bottom part uncompacted and loose. If bridging is going to occur it will do so almost immediately (within 2 or 3 passes of the roller). The lift may appear to be uniformly compacted, but the bottom of the lift will not be dense.

CIRCLE THE CORRECT ANSWER:

3-25 Bridging is a sign that the lift (is / is not) uniformly compacted.

3-27 Walk out

Since bridging is not obvious, your first sign of poor compaction will usually be a failing density test.

Probable causes of bridging include:

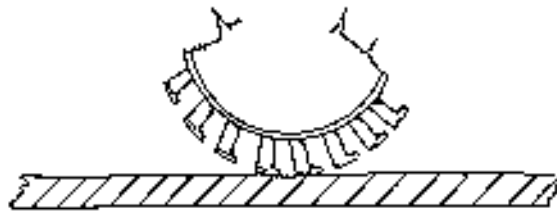
- feet that are too short
 - feet that are worn or broken
 - feet that are too large to penetrate
 - an improperly loaded drum
 - very dry material in the lift
-

Since feet on the rollers vary in length, shape, and surface areas, the contractor should use the type of roller that is best for the material he is compacting. If a roller has the proper type of feet for the particular material, then the cause for a failing density test could be one of the last two items listed above.

CIRCLE THE CORRECT ANSWER:

- 3-26 For best results, the moisture level for untreated aggregate base course material should be
- a. at or near minimum
 - b. at or near optimum
 - c. 5% of optimum).
-

A roller should obtain uniform compaction in 6 to 8 passes. (A pass is one coverage over a certain length of roadway by the particular piece of equipment - a sheepfoot roller in this instance). As the number of passes increases, the feet of the roller will penetrate less and less. On the final pass, the feet will hardly penetrate at all, thus the term "walking out"



3-24 Can

FILL IN THE BLANK:

3-27 As we mentioned earlier, the roller will " _____ " as compaction is achieved.

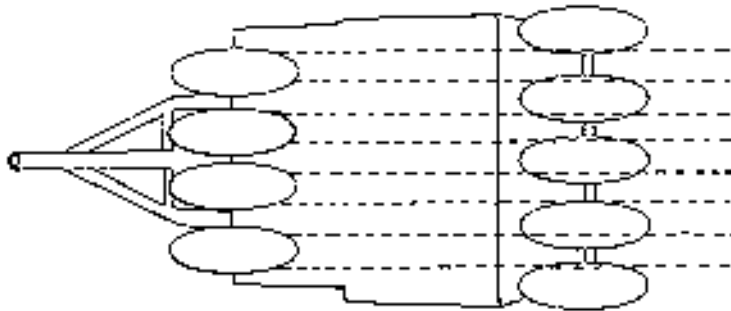
Each lift should be uniformly compacted to the required density. If a lift has the correct gradation and moisture content, and the contractor uses the proper rollers, a uniformly high density is usually fairly easy to obtain.

Another piece of compaction equipment the contractor might use is the pneumatic roller:



The pneumatic roller is usually used to seal the surface of base course materials. It is not normally used for obtaining compaction. The sheepfoot roller is more efficient for thick lifts because its feet can penetrate to the bottom of the lift.

A pneumatic roller is equipped with rubber tires on the front and rear axles. When the pneumatic roller is operating, the gaps between the front tires are covered by the rear tires.

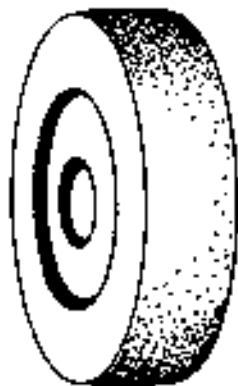


In this way, the entire area of the pass is covered. The material not covered by the front tires will be covered by the rear tires.

CIRCLE TRUE OR FALSE

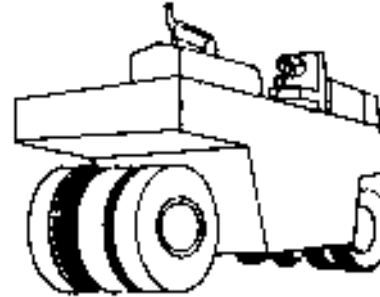
3-28 True False The tires on the pneumatic roller cover the entire surface of the pass.

The tires on the pneumatic roller have no treads. The surface of each tire must be smooth and without nicks or cuts. All of the tires on the pneumatic roller must be equal in diameter, and all must be uniformly inflated.

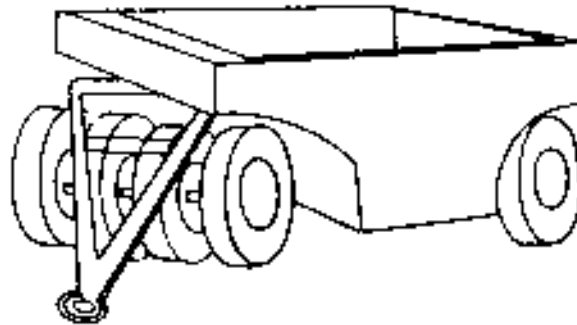


3-26 At or near optimum

Pneumatic rollers may either be a larger, self-propelled roller



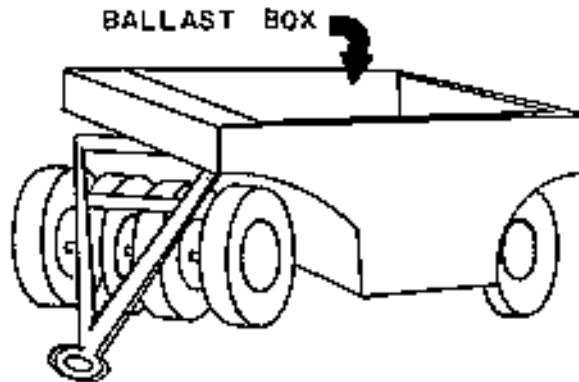
or a smaller roller that is usually towed.



3-30 Finish the surface on an untreated aggregate base course

The compactive effort of all pneumatic rollers may be increased by either increasing the tire pressure or by adding weight. If the contractor decides to increase the tire pressure, he will add more air to the tires. You should check to see that all the tires on a pneumatic roller have equal pressure.

If the contractor decides to increase the compactive effort by adding weight, he will add sand or pieces of concrete to the ballast box. It may be necessary to increase the air pressure of the tires when weight is added. If the air pressure in the tires is not high enough, the only effect adding weight to the ballast box will have is to increase the ground surface covered by each tire.



3-28 True

As the inspector, you can make sure that the pneumatic roller's compactive effort is evenly distributed by seeing that:

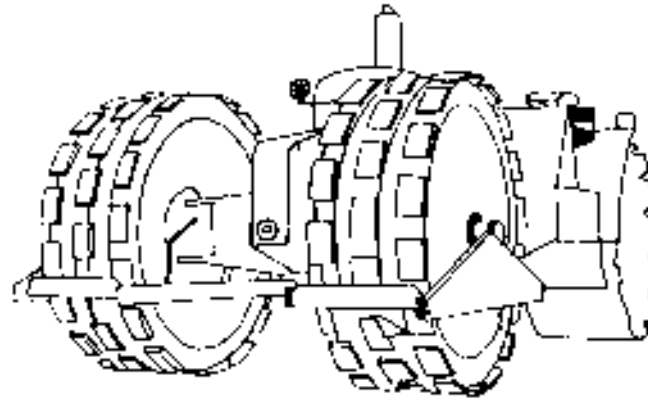
- the pressure of all tires is equal
- no tire is flat
- the added weight load is centered
- all tires are equal in diameter

FILL IN THE BLANK(S):

3-29 To be able to achieve uniform compaction, the tires of the pneumatic rollers must have equal _____, the weight load must be _____, all tires must be equal in _____, and no tire should be _____.

- 3-36 A. Vibratory roller
 B. Pneumatic roller

The waffle-wheel compactor is another piece of equipment used for compacting. It is sometimes used to finish the surface of untreated aggregate base courses.

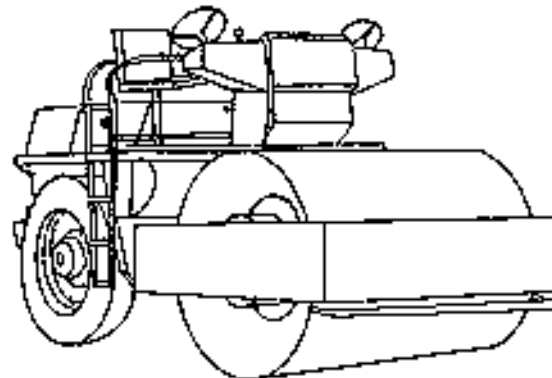


A waffle-wheel compactor is a self-propelled roller having four wheels, each of which is equipped with spaced metal plates. Be sure to check the metal plates - all of them must be in good condition. None must be broken, missing or badly worn. If you see worn plates on a compactor, notify the contractor. These plates should be replaced before compaction begins.

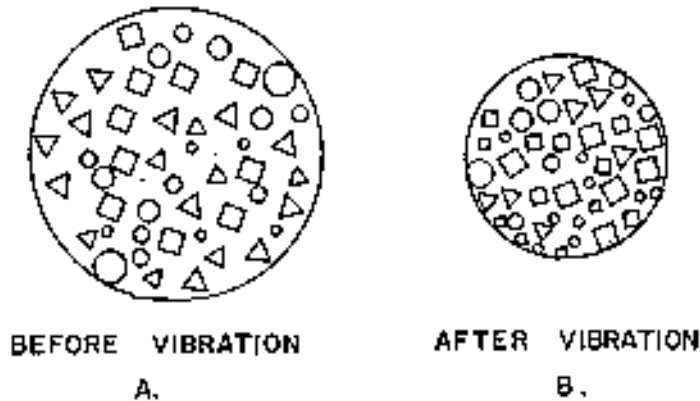
FILL IN THE BLANK(S):

3-30 A waffle-wheel compactor is sometimes used to _____.

This piece of equipment is called the vibratory roller, and is used to compact granular type material.



The vibratory roller compacts material by vibrating the soil particles. Vibration rearranges the particles so they fit together more closely. The following sketches show how soil looks before and after vibration:



3-29 Pressure
Centered
Diameter
Flat

FILL IN THE BLANK(S):

3-31 View _____ from previous drawing, shows the denser soil.

3-32 What type of material is the vibratory roller commonly used for?

The vibratory roller should vibrate at a certain frequency. Frequency is the number of vibrations per minute. If the vibratory roller does not have the correct frequency, it will not compact properly. The manufacturer will recommend the best frequency for the vibratory roller.

The contractor is responsible for seeing that the vibratory roller is operating at the proper frequency. You should notify his foreman if the required density is not being reached so that the proper adjustments can be made.

ANSWER THE QUESTION(S):

3-33 What is frequency? _____.

3-34 The vibratory roller compacts by doing what to the soil particles? _____

3-35 What could be wrong with a vibratory roller that does not compact properly?

Now to review the most common uses of the four pieces of compaction equipment we have just talked about. Remember no one piece of equipment is equally suitable for all untreated aggregate materials. Each one is more effective for a certain type of untreated aggregate material.

For example:

The sheepfoot roller is more effective when compacting materials that are spread in thick lifts and materials with a high binder (clay) content.

The pneumatic roller is more effective when compacting materials that are spread in thin (2-inch to 3-inch) lifts and the top of a lift.

3-37 100% of maximum density

The waffle-wheel compactor is commonly used to finish the surface of untreated aggregate base courses.

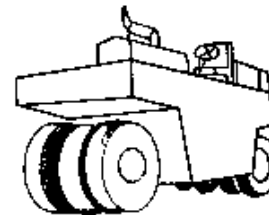
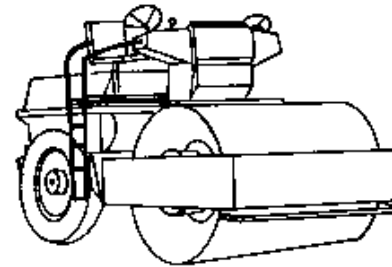
3-38 Before

The vibratory roller is more effective when compacting granular materials, such as graded aggregate.

The contractor is usually free to choose which equipment he'll use. However, if the Special Provisions list specific compaction equipment for a job, the contractor is required to use that equipment.

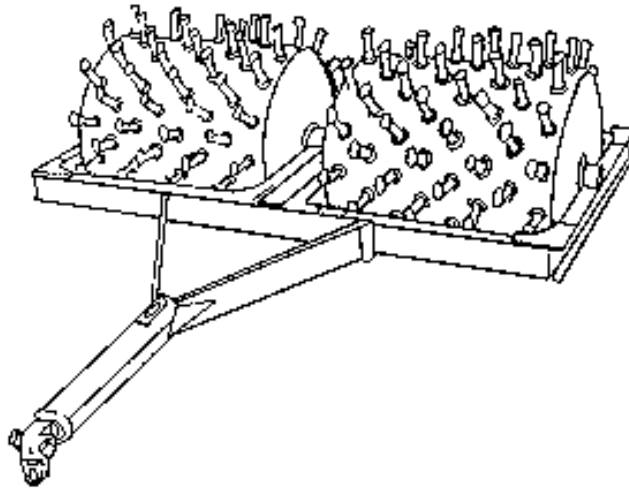
3-36 Label the following pieces of compaction equipment.

A. (picture below) _____



B. (picture above) _____

C. (picture below) _____



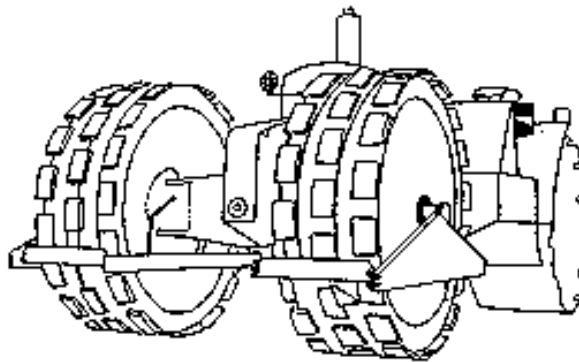
3-31 B

3-32 Granular

3-33 The number of vibrations per minute

3-34 Rearranging

3-35 May be operating at improper frequency



D. (picture above) _____

- 3-44 theoretical
- 3-45 additional
- 3-46 Average
- 3-47 A. No
B. Yes
C. No

Each lift of a multi-layered base course must be spread and compacted to the required density before the next lift is placed. Each type of base course material has a required density as seen in the appropriate section of the Standard Specifications. Notice that the various untreated aggregate base courses are required to reach 100% of maximum density during compaction. Each lift must meet this required density.

FILL IN THE BLANK:

3-37 The density required for an untreated aggregate base course is

CIRCLE THE CORRECT ANSWER:

3-38 Each lift must reach required density (before / after) the next lift is placed.

An in-place density test determines the percent of theoretical maximum density a roadway has actually reached after compaction. The procedure can be found in the Sampling, Testing, and Inspection Manual. One density test should be taken for every 1500 linear feet per 2 lanes of roadway.

Density tests are taken at random locations. If one particular location is always chosen to run the tests (for example, at centerline) you cannot be sure that the entire area meets density requirements. Even if the centerline meets requirements, the whole roadway may not.

Before a density test is taken:

All areas of the base must have received the same compactive effort.
The base must have a uniform appearance.

The contractor should be required to correct all soft, wet, dry, or yielding spots in the base before random testing begins. The surface is dry enough to be tested when fines do not readily stick to your palm. If fines and moisture remain on your palm after you touch the surface of the lift, wait and give it time to dry.

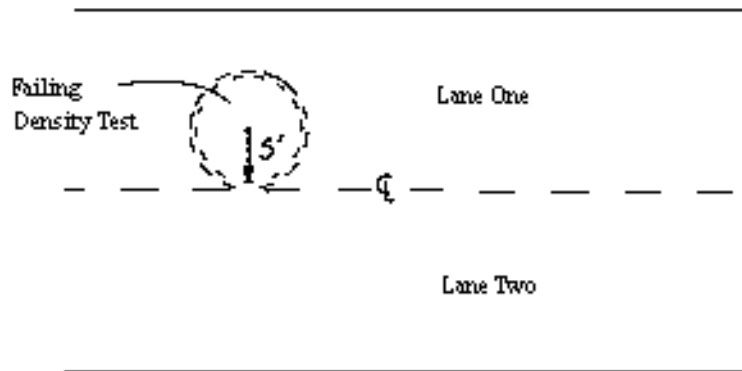
The results of an in-place density test on an untreated aggregate material are compared to the material's theoretical density as shown on the maximum density curve. O M & R personnel advise construction personnel whether the density fails or passes. All the actual test information is then sent to the Area Engineer.

Actual in-place density should at least equal the theoretical maximum density shown on the maximum density curve.

ANSWER THE QUESTION(S):

- 3-39 Material A has a theoretical maximum density as shown on the total material curve of 140 pounds per cubic foot. Its in-place density must be at least _____ pounds per cubic foot.
- 3-40 Material B has a theoretical maximum density as shown on the total material curve of 130 pounds per cubic foot. Its in-place density must be at least _____ pounds per cubic foot.
- 3-41 Material C has a theoretical maximum density as shown on the total material curve of 110 pounds per cubic foot. Its in-place density must be at least _____ pounds per cubic foot.

If a density test taken shows that in-place density is less than the theoretical maximum density, you have a failing density test. Additional testing will then be done.



- 3-36 C. Sheepfoot roller
D. Waffle-wheel compactor

FILL IN THE BLANK(S):

- 3-42 If in-place density is _____ than theoretical density the test failed.
- 3-43 If a failing test happens, density tests then must be _____ .

3-48 Nuclear

3-49 It failed because it was "too dry"

3-50 The second check was a recheck of the failing area after additional water had been added and work had been done.

After taking two additional tests in the area of a failing test, the average percent compaction for the three tests is reported.

For example: Suppose the theoretical density of a material tested is 130 pounds per cubic foot. The first test fails with 128 pounds per cubic foot. The second test shows a density of 125 pounds per cubic foot, and the third shows 127 pounds per cubic foot. The three are averaged:

$128 / 130 = .9846 = 98\%$ of theoretical density

$125 / 130 = .9615 = 96\%$ of theoretical density

$127 / 130 = .9769 = 98\%$ of theoretical density

$(98 + 96 + 98) / 3 = 97.3$, so the average of the three tests is 97% of theoretical density.

FILL IN THE BLANK(S):

3-44 When running a density test, actual density of the material is compared to its _____ density.

3-45 If the test fails, _____ tests must be run.

CIRCLE THE CORRECT ANSWER:

3-46 You must report the (total / average) of all the tests.

If the average of three density tests in a failing test area is less than theoretical density, the contractor must be notified and he must rework and recompact the failing area until the required density is reached.

Suppose theoretical maximum density for an untreated aggregate base course is 116 pounds per cubic foot. Below are listed actual in-place densities for three zones.

ANSWER YES OR NO:

3-47 Which set of densities have an average that meets the density requirements for this base course?

_____ A. 112, 110, and 117 pounds per cubic foot

_____ B. 111, 119, and 118 pounds per cubic foot

_____ C. 117, 104, and 118 pounds per cubic foot

After each density test is taken, the results are written on DOT Form 386 "Report of Compaction Results, Thickness Measurements and/or Samples Taken." As you can see, it fills several tasks. A sample is shown as follows:

DOT 386 Rev. 7-75

DEPARTMENT OF TRANSPORTATION
Office of Materials and Research
Atlanta, Georgia

REPORT OF COMPACTION RESULTS,
THICKNESS MEASUREMENTS AND/OR SAMPLES TAKEN

DISTRICT See PROJECT IFE-108-1 (4) COUNTY WINNETT
PAVING CONTRACTOR SHEPHERD
RESIDENT ENGINEER D. Smith
TESTED BY R. Arnold TITLE T.S. I

DATE OF TEST	ITEM NO. & TYPE OF SAMPLE	SAMPLE NUMBER	DEPTH IN INCHES	SURFACE ELEVATION	SURFACE TEMPERATURE	WATER CONTENT (%)		MOISTURE DENSITY RELATION		WET DENSITY (PCF)	WET DENSITY (KG/M ³)	DESIGN THICKNESS (IN)	THICKNESS MEASURED (IN)	REMARKS
						AS TESTED	ADJUSTED	MAXIMUM	RELATIVE					
7/17	310	1A01	1192.400	N/A	6%	14%	1403	38.3	100%	98.6	E	6 1/2"	E	Too dry
7/17	310	1A02	1192.400	N/A	6%	6.4%	403	142	100%	101.3	E	6 1/2"	P	Recheck

EXPLANATION: 1 - Core, 2 - Road Core, 3 - 12-inch Ring, 4 - Collar Cylinder, 5 - Nuclear, 6 - Recore, 7 - GMD-7, 8 - GMD-67, 9 - ASTM 1559, 10 - Control Study

11 - Sample Taken and Submitted to Lab for Testing
N/A - Not Applicable

Signature: [Signature]
Resident Engineer or Testing Management Technician
Certificate No.: 100 Personal

3-39 140
3-40 130
3-41 110
3-42 less
3-43 taken again

3-51 To obtain a smooth uniform surface.

The previous sample has been filled out for a Base Compaction Test.

Project Information BLOCK contains basic information about the project.

Base is circled because this is a base course sampling.

Dates of test(s) are recorded.

Item No. & Type Material is explained in the Sampling, Testing and Inspection Manual.

Sample Number is based on the District (the first number), the tester's initial (last) and a sequential number, with the numbering system recycling at the beginning of the fiscal year.

In this example "Depth Below Top of Subgrade" is N/A for not applicable.

Under the Moisture or Voids Content (%) column there is "optimum" and an "actual" block. The "optimum" is taken from the maximum dry density determination and the "actual" is the moisture value of the field sample.

The Maximum Dry Density or SP. GR. column has a "Control" and an "In-place" block. The first is the value that has been defined as being the standard for the project and the second is the actual sample value.

Under the Per Cent Compaction column, there are two blocks, one for Required percentage and the Actual. Again, the latter is the actual sample percentage.

Code Designation refers to the symbols in the bottom left and refers to the types of testing that can be used.

The RESULTS block records whether the sample Passed (P) or Failed (F).

ANSWER THE QUESTION(S):

3-48 What kind of device was used in our sample? _____.

3-49 In our example did the first sample Pass or Fail?

3-50 Why was there a second check? _____.

FINISHING

The last step in constructing a raw aggregate base course is the finishing process, which includes fine-blading, sealing, and finally - applying prime to protect the base course. Let's talk about each of these parts of the finishing process:

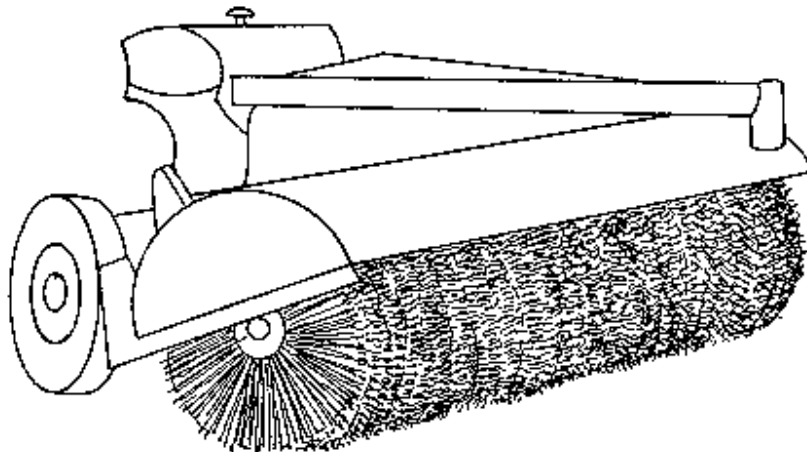
After all lifts of the base course have been compacted to the required density, the top lift must be fine bladed. To fine-blade the surface means to shape the base course to the planned dimensions by scraping off a thin layer of excess compacted material. The surface is freed of dips and humps and becomes smooth. The machine used for fine-blading normally is the motor grader.



Fine-blading helps the base course conform to the following:

- plan distance
 - plan grade and crown
 - plan centerline median
 - plan fore slope and back slope
-

The loose material on the roadway must be brushed away in order for the prime to stick to the base course.



3-52 0.15
0.30
Yard

3-53 Speed

A rotary broom may broom the excess material scraped up during fine-blading off the surface.

The purpose of fine-blading and sealing is to obtain a smooth, uniform surface. You should inspect these operations carefully to be sure all dips and bumps are smoothed out. Visual inspection for irregularities is one of your most important jobs.

FILL IN THE BLANK:

3-51 The purpose of fine-blading and sealing is _____.

APPLICATION OF PRIME

The base course must be protected after the surface has been fine-bladed and sealed. An untreated aggregate base course can be protected by applying an asphaltic material called prime. The prime coat serves to:

keep the base course in finished shape until the surfacing is placed
bond the surface to the base course
act as a moisture barrier because it seals out excess moisture while preventing evaporation
coat the base course and prevent surface fines from being worn away

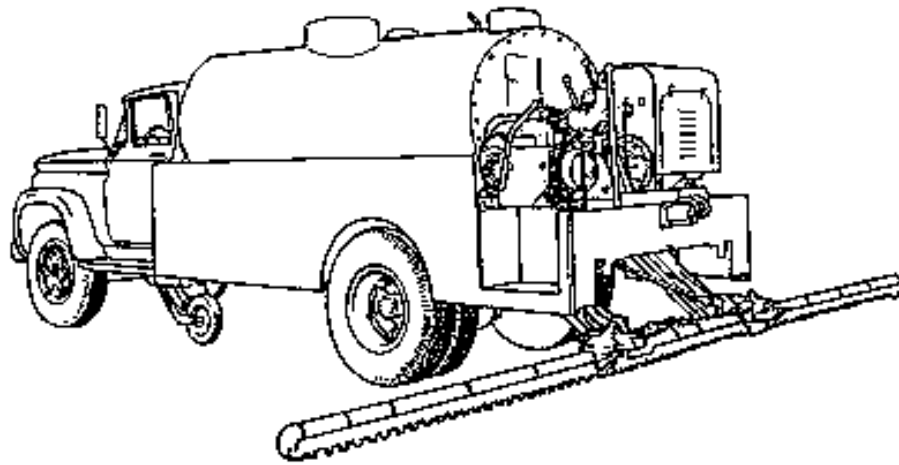
The type of material used for prime on all types of the base material shall be one of those listed in Section 412 of the Standard Specifications as shown below:

Cutback Asphalt	RC-30, RC-70, RC-250, or MC-30, MC-70, MC-250
Emulsified Asphalt	EAP-1
Tars	RT-2, RT-3
Cutback Asphalt Emulsion	CBAE-2

The contractor may use any of the above materials for prime on any type of base.

Before the contractor applies prime, you should inspect the surface of the base course. The surface of the base must be at optimum moisture and must be free of any loose foreign material. If any loose material exists, the base course should be swept with a rotary broom, but be sure that the contractor does not begin sweeping until the surface is dry. Prior to priming, the surface should be damp.

Besides inspecting the surface, you should also inspect the asphalt distributor before it is put into operation. In order to obtain an even application of prime, the distributor must be in good working condition. Look at the following drawing of a distributor.



An asphalt distributor must be able to prime at a specified rate. The application rate for prime is 0.15 to 0.30 gallons per square yard. In order to apply prime at this rate, the distributor must travel at just the right speed.

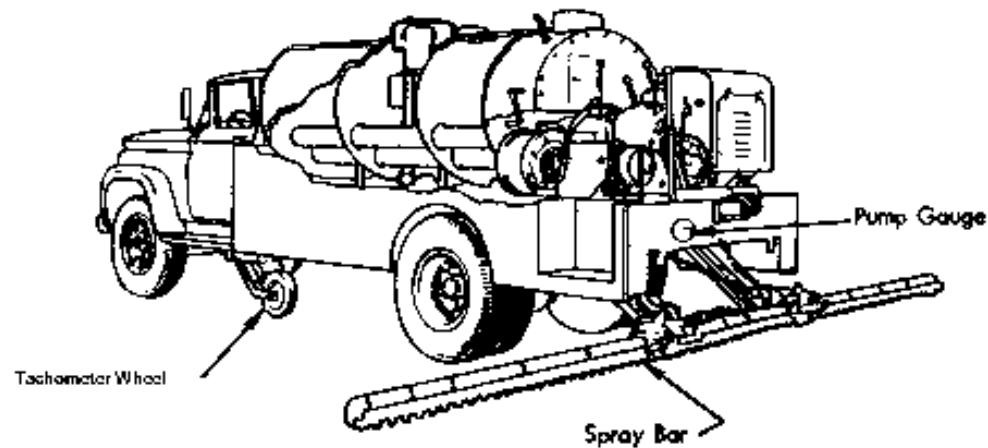
The distributor should have certain devices to help you determine the proper speed:

An application chart or table supplied by the manufacturer. Most of these operate like a slide rule and are calibrated to determine the desired truck speed in feet per minute when you know:

- the length of the spray bar
- the pump capacity in gallons
- the required application rate

A tachometer which records actual speed in feet per minute.

A pump gauge which determines the amount of flow by measuring the amount of pressure.



FILL IN THE BLANK(S):

3-52 The application rate for prime is _____ to _____ gallons per square _____.

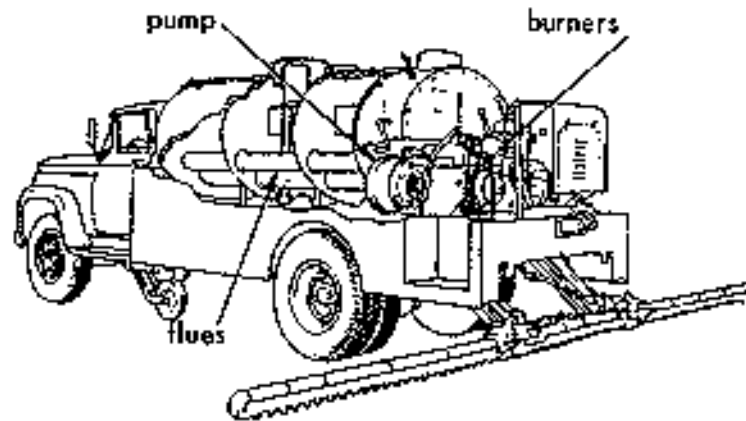
3-53 To obtain the proper application the asphalt distributor must travel at the proper _____.

In addition to applying prime at the specified rate, a distributor must be equipped to heat prime to within a specified temperature range. Unheated prime is stiff and viscous, like tar. It can't obtain complete coverage unless it is uniformly heated to a more liquid state.

Prime is heated to the proper temperature by hot oil or gas burners. These burners distribute the heat to flues that run the length of the tank. A pump is used to circulate the prime through the tank. This causes the prime to be heated uniform at all times.

3-56 Pump

3-57 Nozzles on the spray bar

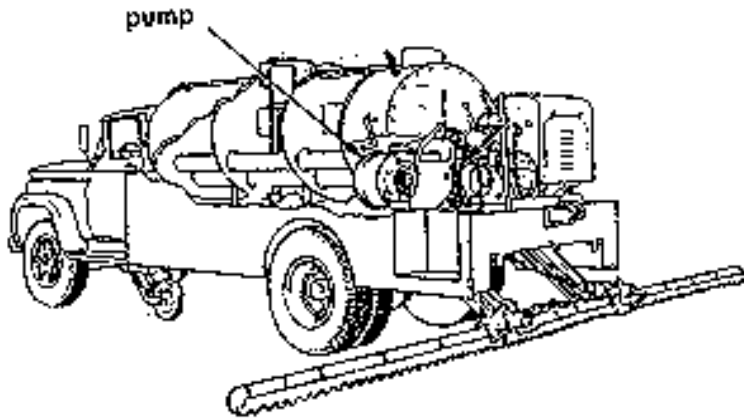


The distributor must also be equipped with a readable thermometer to indicate the temperature of the prime. It will be located on the side of the tank. The temperature range for each type of prime can be found in section 412 of the Standard Specifications. Each time you check the temperature of the prime, it must fall within the specified range.

CIRCLE THE CORRECT ANSWER(S):

- 3-54** To apply prime at a specified rate, an asphalt distributor must be equipped with which of the following?
- a. a bitumen indicator
 - b. a tachometer
 - c. a sludge sieve
 - d. application charts or tables
 - e. a pump gauge
- 3-55** To apply prime within the specified temperature range, an asphalt distributor must be equipped with which of the following?
- a. oil or gas burners
 - b. flues
 - c. a pump
 - d. a readable thermometer

Besides applying prime at a specified rate and temperature range, the distributor must be equipped to maintain constant and uniform pressure on the prime as it passes through the nozzles.



Spray pressure is maintained by a pump. While prime is being "shot," the pump should apply the pressure recommended by the manufacturer's chart for the particular rate of speed.

FILL IN THE BLANK:

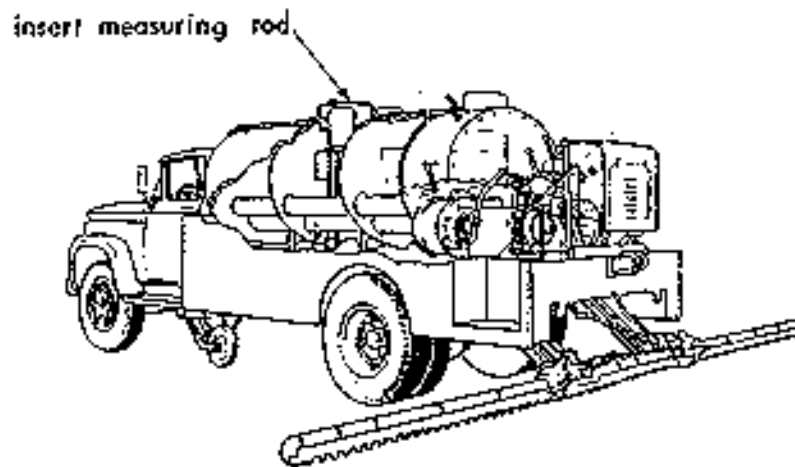
3-56 Spray pressure of prime is maintained by a _____ on the asphalt distributor.

The distributor must also be equipped with screens between the tank and the nozzles. Screens are used to strain the prime so foreign material will not clog the nozzles on the spray bar. If you notice that the area covered by the fans from the spray bar is not uniform, have the distributor shut off.

FILL IN THE BLANK:

3-57 An asphalt distributor should be equipped with screens to prevent the _____ from clogging.

As an inspector, you need to know the exact amount of prime that is in the tank before and after application in order to determine the amount of prime that was shot. For this purpose, an asphalt distributor should be equipped with a meter or a metal measuring rod. The meter or rod is used to determine the quantity carried in the tank at any given time.

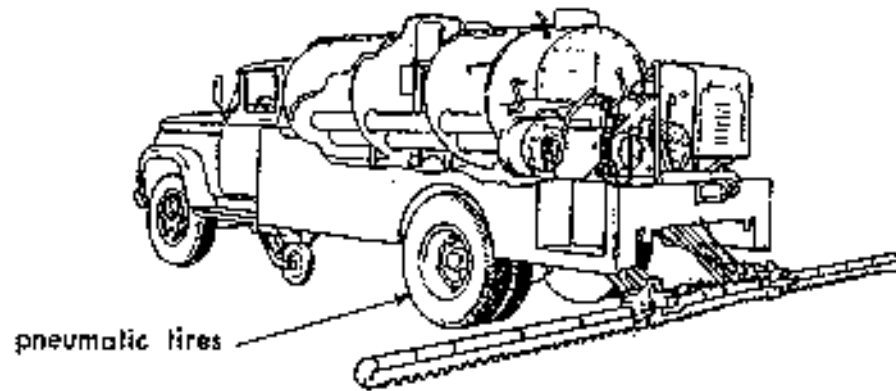


ANSWER THE QUESTION:

3-58 How can you determine the quantity of prime in an asphalt distributor?

_____.

Finally, an asphalt distributor is equipped with pneumatic tires.



3-54 b, d, e

3-55 a, b, c, d

The tires should be wide enough so that the distributor does not cause ruts or depressions in the base course.

When prime is delivered, it has already been approved by the Laboratory - provided that the type, grade and supplier on the invoice are also shown on the qualified supplier list in QPL-7.

The Shipper's Invoice will show all the points called for in SOP-4 .

Shipping		SHIPMENT No. 200909	
SHIPPING NOTICE/MEMO INVOICE			
DATE			
NAME			
ADDRESS			
CITY			
STATE			
ZIP CODE			
TELEPHONE			
FAX			
E-MAIL			
PRODUCT NAME			
QUANTITY			
UNIT			
PRICE			
TOTAL AMOUNT			
TAXES			
TERMS OF PAYMENT			
INCOTERMS			
PACKAGING			
MARKS AND LABELS			
COMMENTS			

The Shipper's Invoice should also be dated. It should indicate the quantity of prime in the shipment, the type of asphalt, and the project and contract ID numbers. The invoice serves as the means of acceptance of the prime, so be sure that data on the form conforms to the requirements in SOP-4.

It is not necessary to obtain job control samples of the prime unless questionable material is involved or possible unsatisfactory performance. In these instances, samples should be submitted for testing, and all interested personnel (supplier, contractor, etc.) should be informed.

An approved supplier's shipment invoice should indicate:

- the date
- the gallons of prime in the shipment
- the project and contract ID numbers
- the type and grade of asphalt
- supplier's name
- gross weight of load and not weight of material
- specific gravity at 60°F
- brand name, percentage, and number of gallons of anti-stripping additive
- brand name and amount of silicone (if applicable)
- CPW Seal

Invoice and Bill of Lading should be stamped or marked "Certified to meet Department of Transportation Specifications".

3-58 By reading a meter or metal measuring rod

The base course has been fine-bladed and sealed and it has the correct moisture for priming. You have inspected the distributor and received the proper forms, but you still aren't ready to begin priming because you haven't checked the outside air temperature. Prime must not be applied when the temperature of the air is less than 40°F in the shade.

As you remember, unheated prime is thick and viscous. To provide good coverage, it must be heated and applied under pressure in a liquid state. If the outside air temperature is below 40°F, the prime will cool while it is being shot. It probably will not obtain good coverage.

FILL IN THE BLANK:

3-59 Prime must not be applied when the outside air temperature is below _____ in the shade.

We mentioned earlier that prime must be spread at a certain rate of application - 0.15 to 0.30 gallons per square yard. Thus, the contractor must spread a minimum of 0.15 gallons per square yard and a maximum of 0.30 gallons per square yard in order to meet specifications. As the inspector, your job is to make sure that the actual amount applied is within this range. The following sections are concerned with determining the actual spread rate.

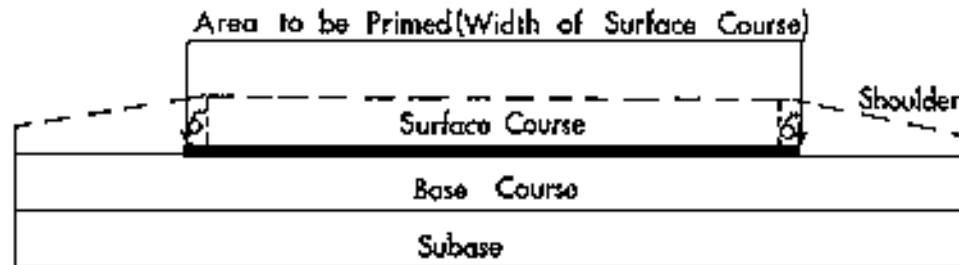
One of the first steps in determining the actual spread rate is to find the area of the section of base course being primed (Length X Width). To find the width, go to the project plans and find the surface width (not the base course width). Prime is not applied to the entire width of the base course because shoulders of 3 to 10 feet wide will be placed on each side of the surface course. The width of the prime application will be the width of the surface course plus 6 inches on each side.

3-62 1470.15 gallons

3-63 60°F
Square yards

3-64 0.15
0.30

3-65 0.28



The Standard Specifications state that prime must be applied 6 inches beyond the width of surfacing shown on the plans." Actually, this means 6 inches on each edge of the plan surface width, or a total of 1 foot must be added.

FILL IN THE BLANK:

3-60 Suppose the plan surface width is 20 feet. The total width to be primed is _____ feet.

To determine length, all you need to do is multiply the number of Stations being primed by 100 feet. For example, Stations 70+00 to 75+00 are being primed; therefore, 5 X 100 feet = 500 feet (total linear feet being primed).

You can now determine the area by multiplying length x width. For example, if the length = 500 feet, and width = 29 feet, then 500 feet X 29 feet = 14,500 square feet. Dividing 14,500 square feet by 9 gives a total of 1,611 square yards.

ANSWER THE QUESTION:

3-61 How many square yards are to be primed if the plan width of the surface course is 23 feet and Stations 61+00 to 86+00 are to be primed?

The next step in determining the actual spread rate is to find the number of gallons actually used. This is not difficult. Before the contractor begins to shoot prime, you must record the beginning quantity (in gallons) as indicated on the asphalt distributor's meter or measuring rod. As soon as the application of prime has been made, record the ending quantity. Subtract the ending quantity from the beginning quantity and you'll have the amount of prime actually used.

Beginning quantity, ending quantity, and application temperature should be documented in a field book or on the inspector's report, as these figures are used to compute the actual spread quantity.

Prime may be shot at any temperature from 80°F to 180°F, depending on the type. Prime heated over 60°F expands, and more gallons must be used to cover the same area of base. The distributor will have to spread it at a slower rate of speed in order for the base course to be properly covered.

The Standard Specifications set the temperature of pay quantity of prime at 60°F; therefore, if it is shot at another temperature, the gallons used must be converted to liters at 60°F. To convert heated prime to liters at 60°F, it will be necessary to use the correction chart that follows.

This chart is taken from Section IV of the Construction Manual.

Attachment No. 1

TABLE 3
E-VOLUME CORRECTIONS FOR ASPHALT MATERIALS
SPECIFIC GRAVITY AT 60°C F. ABOVE 0.966

TEMPERATURE

ACTUAL TEMP.	FACTOR	ACTUAL TEMP.	FACTOR	ACTUAL TEMP.	FACTOR	ACTUAL TEMP.	FACTOR
60	1.000G	113	.981e	166	.9642	219	.9473
61	.9997	114	.9835	167	.9639	220	.9470
62	.9993	115	.98-1	168	.9636	221	.9467
63	.9986	1176	.9808	170	.9629	222	.9460
65	.9983	118	.gBol	171	.9626	224	.9457
66	.9979	119	.9798	172	.9623	225	.9454
67	.9976	120	.9794	173	.9620	226	.9451
68	.9972	121	.9791	174	.9616	227	.9448
69	.9969	122	.9788	175	.9613	228	.9445
70	.9965	123	.9784	176	.9610	229	.9442
71	.9962	124	.9781	177	.9607	230	.9436
72	.9958	125	.9778	178	.9603	231	.9435
73	.9955	126	.9774	179	.9600	232	.9432
74	.9951	127	.9771	180	.9597	233	.9429
75	.9948	128	.9768	181	.9594	234	.9426
77	.9941	1320	.97764	18832	.5897	236	.9420
78	.9937	131	.9758	184	.9584	237	.9417
79	.9934	132	.9754	185	.9581	238	.9414
80	.9930	133	.9751	186	.9578	239	.9410
81	.9927	134	.9748	187	.9574	240	.9407
82	.9924	135	.9744	1e8	.9571	241	.9404
83	.9920	136	.9741	189	.9568	242	.9401
84	.9917	137	.9738	190	.9565	243	.939d
85	.9913	138	.9734	191	.95-2	244	.9395
86	.9910	139	.9731	192	.9558	245	.9392
87	.9906	140	.9728	193	.9555	246	.9389
88	.9903	141	.9724	194	.5552	247	.9386
89	.9900	142	.9721	195	.9549	248	.9383
90	.9896	143	.9718	196	.9546	249	.9380
91	.9893	144	.9714	197	.9542	250	.9376
92	.9889	145	.9711	198	.9539	251	.9373
93	.9886	146	.9708	199	.9536	252	.9370
94	.9882	147	.9704	200	.9533	253	.9367
95	.9879	148	.9701	201	.9530	254	.9364
96	.9876	149	.9698	202	.9527	255	.9361
97	.9872	150	.9695	203	.9523	256	.9358
98	.9869	151	.9691	204	.9520	257	.9355
99	.9865	152	.9688	205	.9517	258	.9352
100	.9862	153	.9685	206	.9514	259	.9349
101	.9859	154	.9681	207	.9511	260	.9346
102	.9855	155	.9678	208	.9508	261	.9343
103	.9852	156	.9675	209	.9504	267	.9340
104	.9848	157	.9672	210	.9501	263	.9337
105	.9845	158	.966B	211	.9498	264	.9334
106	.9842	159	.9665	212	.9495	265	.9331
107	.9830	160	.9662	213	.9492	266	.9327
108	.9835	161	.96-9 I	214	.9489	267	.9324
109	.9831	162	.9655	215	.gh85	268	.9321
110	.9828	163	.9652	216	.94d2	269	.9318
111	.9825	164	.9649	217	.9479	270	.9315
112	.9823	165	.9646	218	.947G	271	.9312

3-59 40°F

- 3-74 Closed to traffic
- 3-75 Prime

The numbers in the temperature column are possible temperatures for prime in consecutive order.
The numbers in the factor column are correction factors for the temperature shown, at certain Specific Gravities.

Go to the temperature column that corresponds to the temperature of prime you are working with. Multiply the correction factor for this temperature by the gallons of prime actually used.

CALCULATE THE ANSWER:

3-62 If you shot 1,500 gallons at 115°F with a Specific Gravity of .976, the volume corrected to °F is _____ gallons.

Now, the final step to find the actual rate of application is to divide the number of gallons of prime at 60°F by the number of square yards in the section. The resulting figure should be between 0.15 and 0.30 in order to comply with the rate of application stated in the Standard Specifications.

FILL IN THE BLANK(S):

3-63 To find the rate of application per square yard, divide the number of gallons at _____ by the number of _____ in the section.

3-64 The rate of application must be between _____ and _____ gallons per square yard.

3-65 Calculate the actual rate of application of cutback using the following information:
Prime is shot from Station 45+00 to Station 65+00.
The width of the plan surface area is 22 feet.
The gauge on the asphalt distributor tank measures 2,000 gallons before the prime is shot and 500 gallons afterwards.
The thermometer is on 146°F at the time of application.
The Specific Gravity of the prime is .966.

Answer: _____ gallons per square yard.

Now we're ready for documentation. Below is an example of all the items you may need to document when prime is being shot. This would be in your payment documentation or in a separate field book.

BASE COURSE - APPLICATION OF PRIME

Item # ()
Stations Covered
Linear feet
Width
Square yards
Beginning Quantity
Ending Quantity
Gallons Used
Application Temperature
Gallons Corrected to 60°F
Rate of Application
Haul Ticket Number
Date

ANSWER THE FOLLOWING QUESTIONS:

- 3-66 Multiply the number of Stations by _____ to find the number of linear feet covered.
- 3-67 The width is the width shown on the project plans plus _____.
- 3-68 Multiply _____ by _____ to find the area covered.
- 3-69 Beginning and ending quantities of prime in the distributor were taken from the _____ on the distributor.
- 3-70 The _____ minus the _____ equals the number of gallons actually used.
- 3-71 The temperature of prime must be between _____ and _____ in order to be used.
- 3-72 Multiply the correction factor by the number of _____ to find the number of liters at 60°F.
- 3-73 To find the rate of application divide the number of _____ by the number of _____.
-

MAINTENANCE OF AN UNTREATED AGGREGATE BASE COURSE

If possible, the base course should be closed to traffic until the prime cures. After the prime has cured, the contractor will probably clear the roadway of debris and excess material. He should clean and dress the slopes and ditches as much as possible before the surface course is placed. This prevents possible damage to the completed surface course.

FILL IN THE BLANK:

3-74 The base course should be _____ until the prime has cured.

3-78 Hot mix

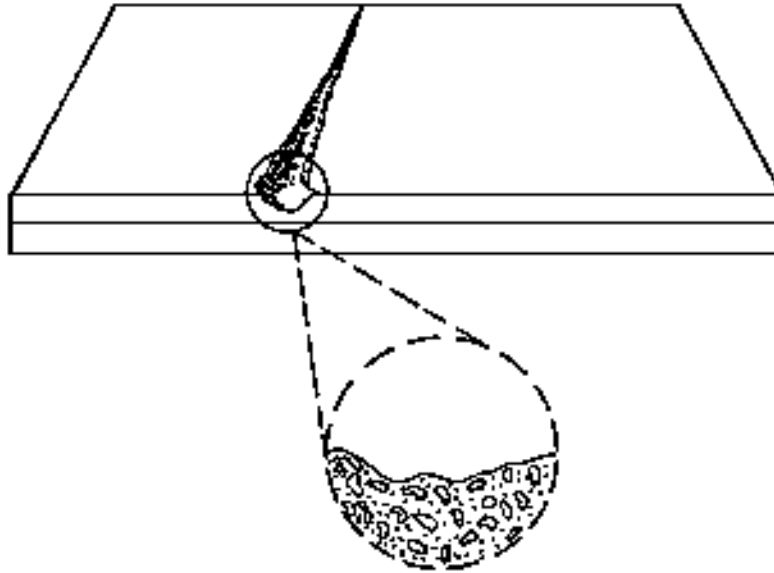
- 3-79
1. B
 2. C
 3. D
 4. D
 5. A

The contractor is responsible for maintaining the completed base course against damage caused by traffic. As an inspector, you should help him out by notifying him of any areas that need repairs. You can check the condition of the base course and prime coat regularly and make a record of all areas where prime is stripped off or where defects are evident in the base course. Be sure to document any corrective action taken.

FILL IN THE BLANK(S):

3-75 You should make a record of all areas where _____ is stripped off or where _____ are evident in the base course. You should notify the _____ of areas that need repair.

If a base course is allowed to stand several months before surfacing, it is possible that raveling will take place. Raveling is a defect that occurs when prime is stripped off and fines are worn away, leaving exposed coarse aggregate. Raveling usually occurs in longitudinal strips on the base surface. The following cross section illustrates raveling:



Where raveling has occurred, the area is usually repaired by removing loose material and applying asphaltic material (hot mix) which is rolled in uniformly with the tandem or pneumatic roller.

CIRCLE THE CORRECT ANSWER:

3-76 Raveling usually occurs in (diagonal cross-patterns/longitudinal strips) on the surface of the base course.

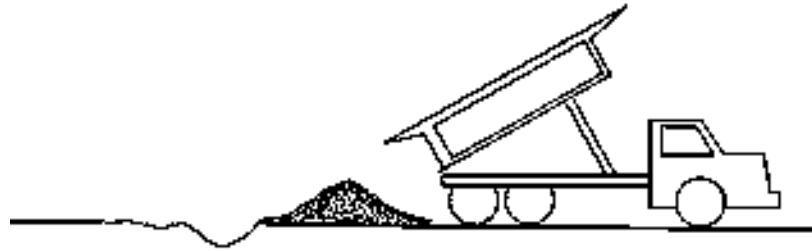
FILL IN THE BLANK:

3-77 Raveled areas are usually repaired by_____.

Shallow, base defects such as depressions (low spots) are repaired by removing to traffic loose material and applying hot mix.

- 3-66 100
- 3-67 1 foot
- 3-68 Length
Width
- 3-69 Meter (or measuring rod)
- 3-70 Beginning quantity
Ending quantity
- 3-71 80°F
180°F
- 3-72 Gallons used
- 3-73 Gallons at 60°F
Square yards covered

3-82 280.3 linear feet



FILL IN THE BLANK:

3-78 _____ is used to repair shallow base defects.

Large defective areas in an untreated base course may be reworked, recompact and reprimed. As an inspector, you are responsible for seeing that the base course is properly maintained until the surfacing is placed.

MATCH THE COLUMNS:

3-79 Match column "A" with column "B" below:

	A	B
_____	1. responsible for maintaining and protecting the completed base	A. reworking, recompact and reprimed
_____	2. responsible for seeing that the completed base course is maintained	B. the contractor
_____	3. usual method of repairing raveled areas	C. the inspector
_____	4. usual method of repairing small, shallow defects	D. applying hot mix
_____	5. method of repairing large, defective areas	

STABILIZED BASE COURSES

Stabilized base course material may either be premixed through the use of a pugmill, or mixed-in-place on the roadway. Before construction can start on stabilized bases, the outside temperature away from artificial heat and in the shade must be at least 40°F and rising. If construction is underway and the temperature falls to 35°F, construction must be halted. These temperature requirements should be followed unless special permission is granted.

FILL IN THE BLANK(S):

3-80 Construction of stabilized bases may begin when the outside temperature is _____ and rising, but construction should be halted if the temperature falls to _____.

PLACEMENT OF STABILIZED MATERIALS

Often the base course materials to be stabilized are materials from an existing roadbed. If this is the case, the existing roadbed must be scarified, pulverized, blended, and shaped before stabilization can begin. Section 301 of the Standard Specifications deals with the "In-Place Cement Stabilized Base Course."

If existing roadbed materials are not present, then the materials to be stabilized are hauled in and placed in the same manner as materials for untreated aggregate bases. The materials are spread and uniformly compacted to the satisfaction of the Project Manager.

FILL IN THE BLANK(S):

3-81 If materials to be stabilized are not present, they must be _____, placed, and uniformly _____ prior to stabilization.

Once the material to be stabilized is compacted, cement or lime can be spread and the stabilization process begun. Since cement and lime are spread and cut into the base course materials in the same manner we will discuss only cement. The Central Lab, after testing the materials to be used, will include in their report the percentage of cement needed for proper stabilization as well as the optimum moisture content. It will be up to you to use the information received from the lab properly. If you are in doubt as to how to use the percent of cement go back to Chapter 2 and review.

3-76 Longitudinal strips

3-77 Removing loose material and applying hot mix which is rolled in

CALCULATE THE ANSWER:

- 3-82** Find the cement spread distance if:
Plan depth = 7 inches
Plan width = 23 feet
Proportion of cement = 9%
Weight of cement in transport = 40,000 pounds
Weight of dry soil = 118 pounds per cubic foot

Answer: _____ linear feet

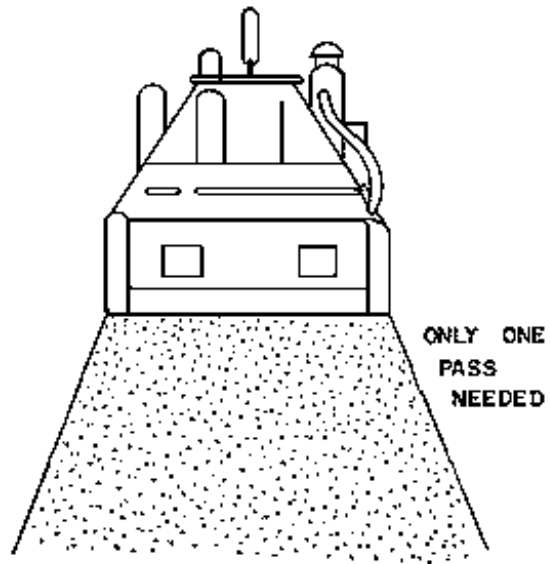
A cement transport should spread a uniform blanket of cement over the materials to be stabilized utilizing a mechanical cement spreader and by operating at a constant slow rate of speed.



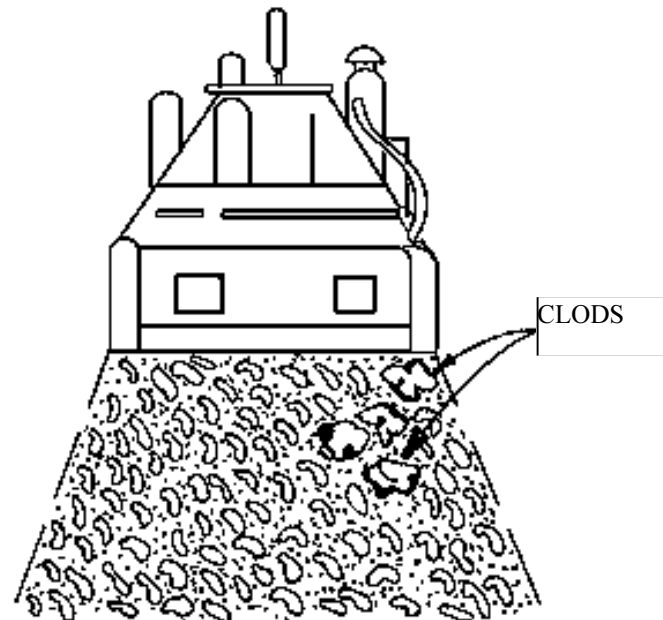
On most roadway materials, only one pass with a single-pass model is needed for a uniform mixture and the required pulverization.

3-83 Mix and pulverize a section of roadway in only one pass

3-84 A high Plasticity Index (P.I.)



But if material with a high Plasticity Index (P.I.) is deposited on the roadway, a single-pass mixer might have to make several passes over the same section.



- | | |
|------|------------------------|
| 3-80 | 40°F
35°F |
| 3-81 | Hauled in
Compacted |

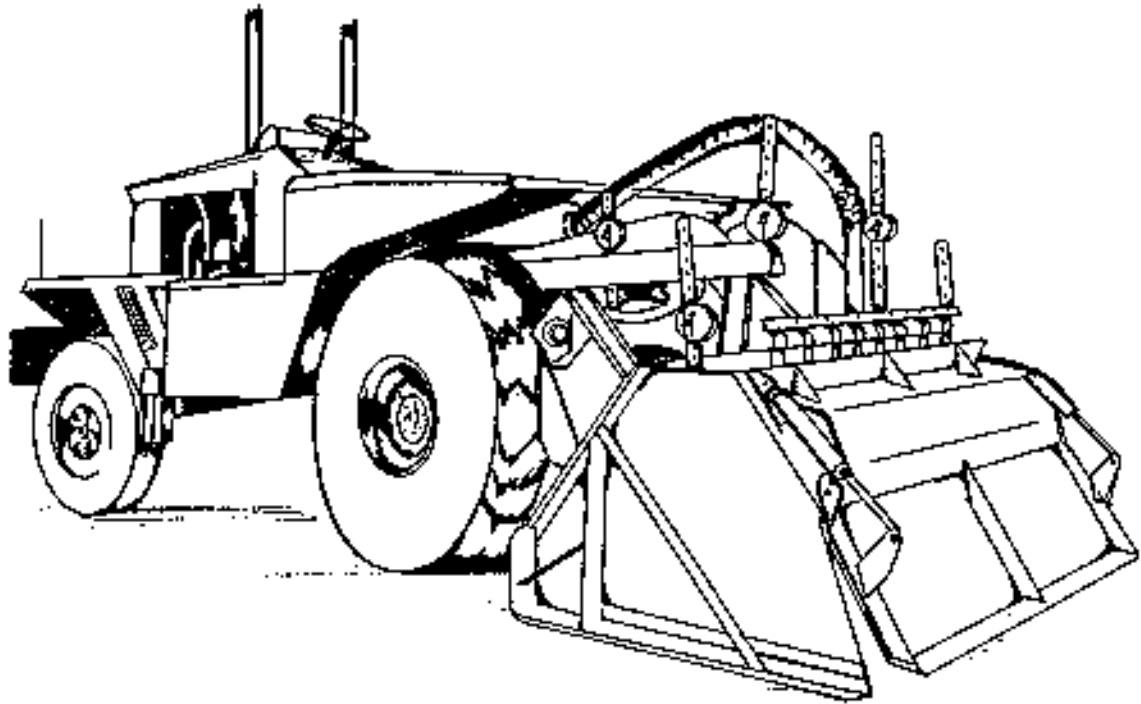
FILL IN THE BLANK(S):

3-83 A mixer is the single-pass type if it can _____.

3-84 A soil condition that might require more than one pass of a single pass mixer is _____.

Another type of mixer is called the multiple-pass mixer. It must usually make several passes over the same section to obtain a uniform mixture and the required pulverization.

3-89 The process of a mixer making a pass over the roadway, cutting the material as it goes.

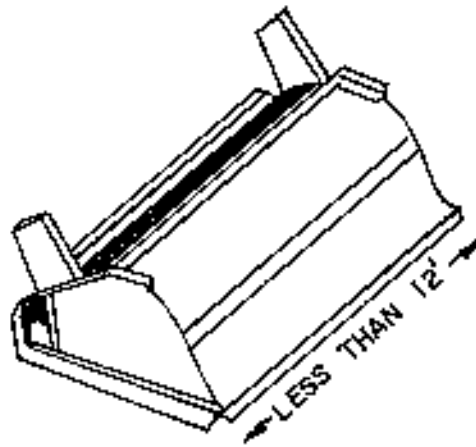


The contractor will decide whether to use a single-pass or a multiple-pass mixer. Single-pass models are more efficient, but they are also more expensive. So whenever possible, the contractor will try to use his multiple-pass machines.

CIRCLE TRUE OR FALSE:

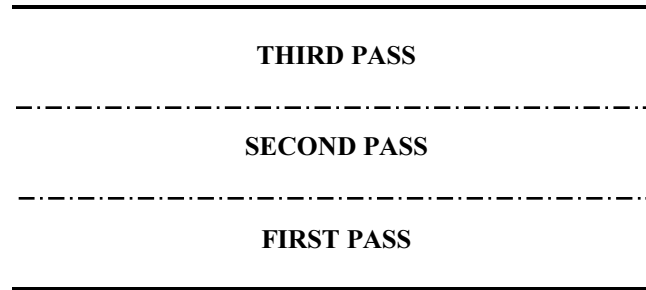
- 3-85 True False It is the inspector's duty to determine the type of mixer used.
- 3-86 True False The most expensive mixer is the multiple-Pass
- 3-87 True False The most efficient mixer is the single-pass
- 3-88 True False Even the single-pass may have to make several passes over the same area.
-

The part of a mixer that blends and pulverizes the materials is called the cutting box. When a mixer makes a pass over the roadway material, cutting the material, we call that a cutting pass. The cutting box of most mixers is usually less than 12 feet wide.



A mixer must make several cutting passes before the entire width of a roadway is covered.

PLAN VIEW



3-92 The cutting overlap is not the minimum 6 inches

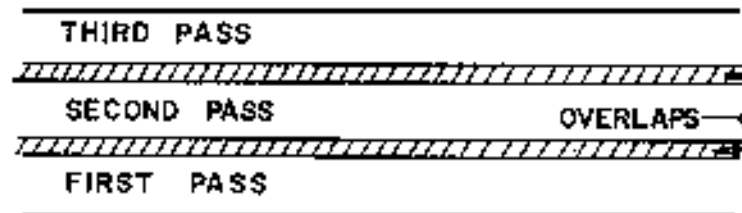
3-93 The 6-inch cutting overlap is not consistent (does not run the entire length of the cutting pass)

ANSWER THE QUESTION:

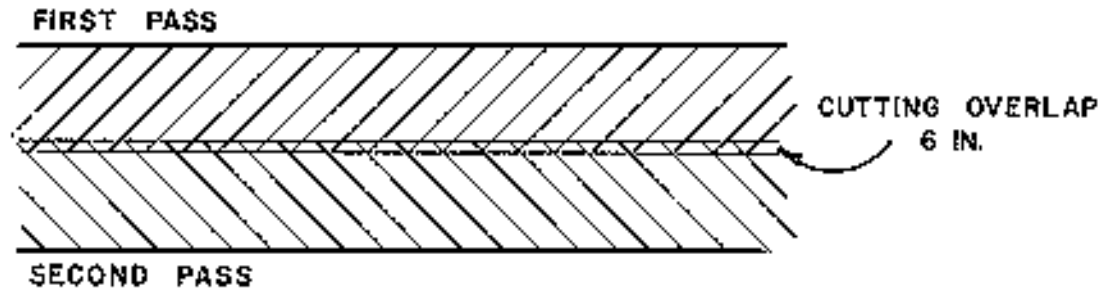
3-89 What is a cutting pass? _____.

You must always inspect the overlap on adjoining cutting passes.

PLAN VIEW



It is your job to see that each cutting pass overlaps the previous one. The amount of overlap in cut material should be a minimum of 6 inches. This is cutting overlap, not cutting box overlap.



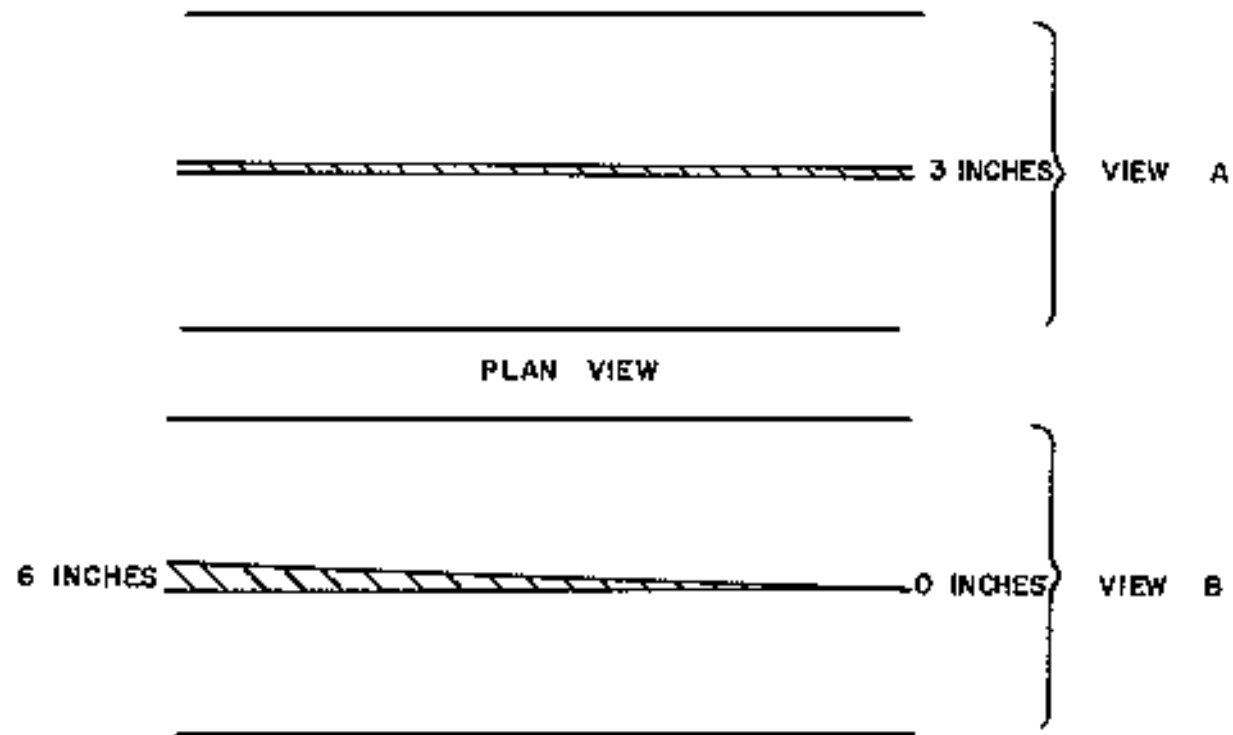
Also, as you can see, the 6-inch overlap should run the entire length of the cutting pass.

ANSWER THE QUESTION:

3-90 Why must a mixer make several cutting passes to cover the width of a roadway?

3-91 What two things should you check for on every cutting pass?

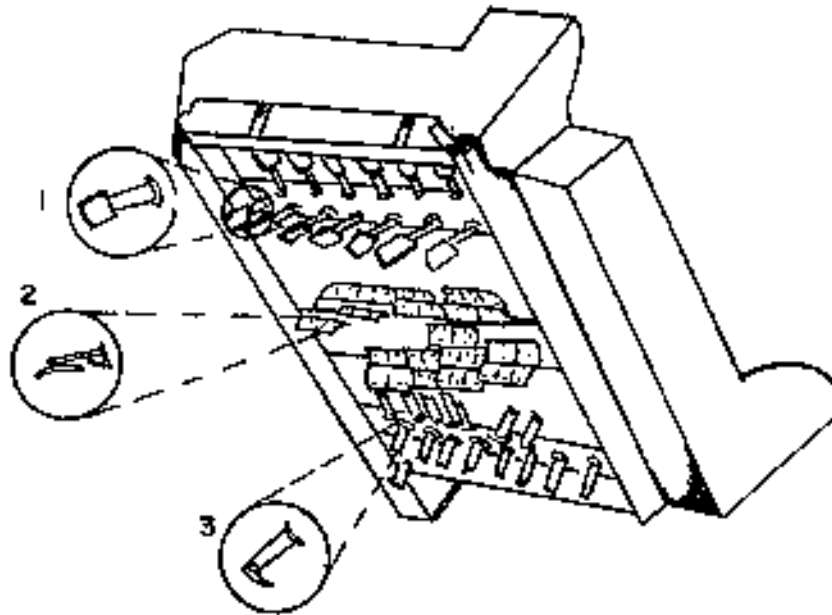
3-94 It contains no clods or streaks
of color or moisture



3-92 What is wrong with the cutting pass in View A?

3-93 What is wrong with the cutting pass in View B?

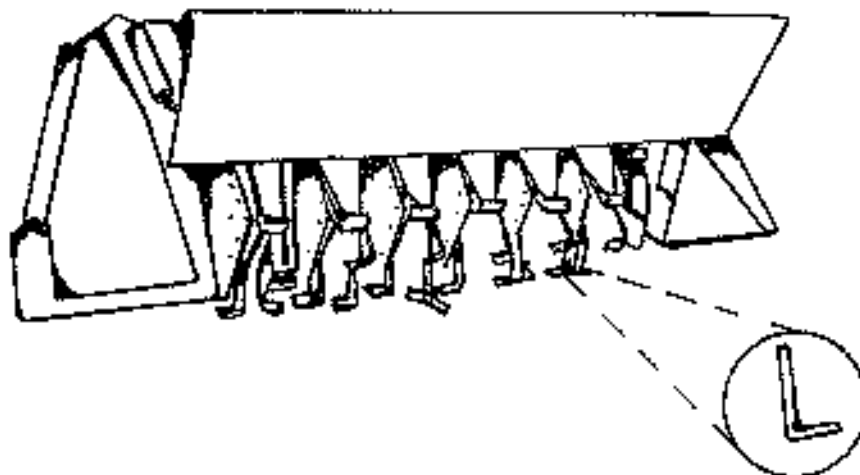
Let's take a closer look at these cutting boxes. This is what you'll see when the box is raised. The single-pass model has three shafts that rotate during a cutting pass. Paddles are attached to each shaft.



3-90 The cutting box is not wide enough to cover the entire width of the roadway

3-91 Each cutting pass should overlap the previous one at least 6 inches and the overlap should run the entire length of the cutting pass

The multiple-pass model has only one rotating shaft equipped with tines instead of paddles.



Both paddles and tines can wear down rapidly during cutting operations. If they wear down too far, they can't mix and pulverize the material properly. During heavy cuttings, a shaft of paddles or tines might have to be changed as often as twice a day. There are two ways of determining whether a shaft of paddles or tines needs changing. First, examine the mixture coming out behind the mixer. This mixture is called fluff. Three things you should look for are: a) the uniformity of the fluff, b) the depth of the fluff, and c) the bottom of the fluff down to the subgrade (dig a narrow trench). It should be uniform.

- 3-95 Will not
- 3-96 Will not
- 3-97 6
Length
- 3-98 The paddles or tines are worn out or the spray bar is clogged
- 3-99 The paddles or tines are worn
- 3-100 Completely across the cutting box



If there are streaks and clods in the fluff after several cutting passes, or if the depth of the cut is too shallow, then paddles or tines probably need to be replaced.

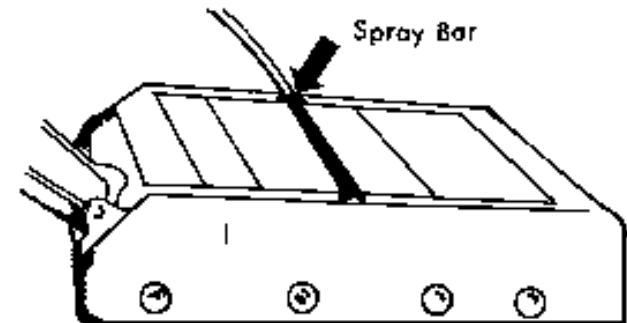
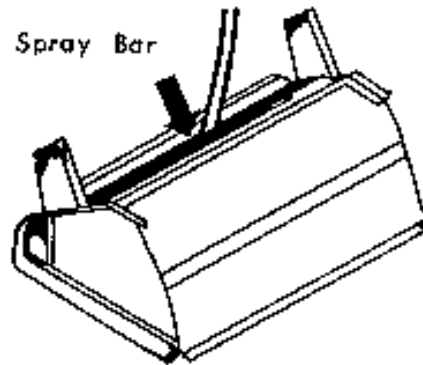
FILL IN THE BLANK:

3-94 Stabilized material is mixed uniformly when _____.

The second way to determine whether a shaft of paddles or tines needs to be replaced is by actually looking under the cutting box. If you see broken or worn paddles or tines then they need to be changed.

A box with a lot of broken and worn paddles cannot mix the material properly. One of your duties is to know when tines or paddles need changing. You do this by looking at the fluff and checking depth of cut. But remember, changing tines or paddles is the contractor's option. He may decide to replace those that are worn, or he may try to achieve a good mix by having the stabilizer make more passes. How he gets a specification mix is his business. Your business is inspecting the mix to see that it does meet specifications.

Here's something else to watch out for:



3-103 As necessary

3-104 Mixing

3-105 80
4

Always make sure that the cutting box on a mixer is equipped with a spray bar. A spray bar is used to add moisture to the mixture when needed. There is a valve that regulates water flow.

CIRCLE THE CORRECT ANSWER:

3-95 If the spray bar does not extend across the cutting box, the mixture (will / will not) be moistened uniformly.

3-96 If the spray bar is clogged, the mixture (will / will not) be moistened uniformly.

FILL IN THE BLANK(S):

3-97 The overlap on adjoining cutting passes must be at least _____ inches, and it must run the entire _____ of the cutting pass.

3-98 Fluff material that shows streaks after several passes indicates _____.

3-99 A shallow depth of cut indicates _____.

3-100 The spray bar on the stabilizer must extend _____.

3-101 The holes must not be _____.

COMPLETE THE DEFINITIONS:

3-102 Write brief definitions to the following:

- a. mixer _____
- b. cutting box _____
- c. fluff _____

A stabilized base course that has been mixed-in-place must also meet certain requirements after mixing and at the time of compaction. These requirements involve the following tests:

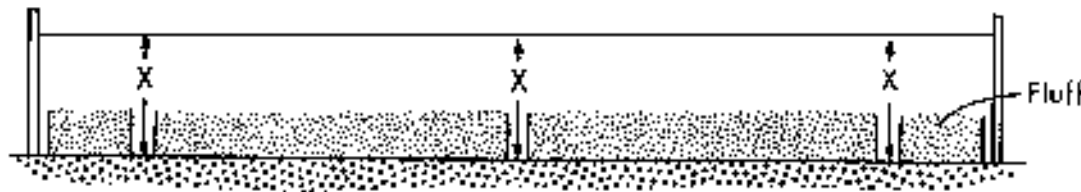
width and depth of the cut
pulverization
moisture content
proctor molds

(Testing procedures are not covered in this course, but we will discuss each of the above tests in general.)

WIDTH AND DEPTH OF CUT

Measurements of thickness (depth) and width taken at this time - immediately after mixing and prior to compaction - are usually referred to as "construction control measurements." These control measurements are checked as necessary to ensure specified materials.

A minimum of three holes are dug across the roadway.



The width measurements are made at the same locations as depth checks and should be the actual width cut and mixed. To find the outside edge of the base course, dig into the material on each edge and locate the hub that was set for horizontal alignment. A metallic tape can then be used to measure the width from outside edge to outside edge.

FILL IN THE BLANK(S):

3-103 Mixed-in-place stabilized bases should be checked for thickness and width _____.

3-104 The initial measurements are taken after the _____ process.

3-108 The distance from the stringline to the prepared subgrade is measured

3-109 False

3-110 True

3-111 False

3-112 False

Pulverized material is acceptable if 100% of the material passes the 1½-inch screen and 80% of the material by total weight exclusive of gravel or stone will pass a No. 4 screen. The O M & R perform this test. The testing method for field determination of pulverization of soil bases can be found in the Sampling, Testing, and Inspection Manual.

Documentation of this test should be as follows:

STA.	LOC.	TOTAL WEIGHT	WEIGHT OF +4	% PULV.		DATE	INITIALS
16+25	8' RT.	5.45	1.16	1½"	No. 4	7/61	JCH

FILL IN THE BLANK(S):

3-105 At least _____ percent of stabilized material must pass a No. _____ screen in order to be acceptable.

The optimum moisture for the mixture is determined by the Laboratory. The actual moisture content should be within 90% to 120% of the specified optimum moisture content at the time of compaction. The method of testing for moisture content can also be found in the Sampling, Testing and Inspection Manual and is also done by the O M & R.

FILL IN THE BLANK(S):

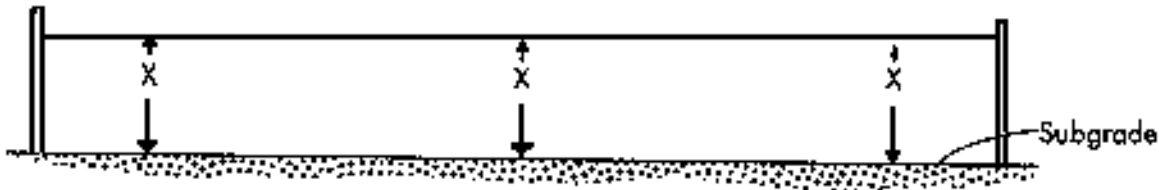
3-106 At the time of compaction, the moisture content of a stabilized base must be within _____ percent of the optimum moisture content.

The next test done by the O m & R is a proctor, which is run on soil in a mold of a given volume. The proctor test is run to find dry weight densities at certain moisture contents. Proctor molds should be taken one per 1,500 feet per 2 lanes.

ANSWER THE QUESTION:

3-107 How many proctor molds should be made?

In order to control the thickness of pugmilled material, you must take measurements before spreading it on the subgrade. A straightedge makes these measurements or a stringline stretched between points of known elevation to the prepared subgrade.



3-101 Clogged

3-102 A. A machine with rotating tines or paddles
B. The piece of equipment which contains the cutting paddles
C. Material mixed by the stabilizer

After compaction of the pugmilled material another measurement is made to determine the thickness (but we'll cover this a little later on).

ANSWER THE QUESTION:

3-108 What step must be taken before spreading to control thickness of pugmilled bases?

You will need to determine when the cement was moist-mixed with the other materials. The construction crew should immediately begin spreading the mixture, as all compaction must be completed within 2 hours after initial mixing of cement with base course materials.

TRUE OR FALSE:

3-109 True False Pugmilled materials must be mixed-in-place on the roadway.

3-110 True False Thickness measurements must begin before pugmilled materials are placed.

3-111 True False Measurements are made from a straightedge or stringline to the bottom of the cut made by the stabilizer.

3-112 True False It is not necessary to know the actual time when cement was moist-mixed with other materials in the pugmill.

Procedures for both pugmilled and mixed-in-place materials are the same after the placement step; therefore, for the remainder of Section II we will discuss the procedures for all stabilized materials.

COMPACTION

As stated earlier, compaction must be completed within 2 hours after the initial mixing of cement with the base course materials. The steel wheel and vibratory steel wheel roller are normally used to begin compaction. Three to six coverages are usually enough if the moisture content and weight of the roller are sufficient.

The pneumatic roller is also used on stabilized bases to compact, smooth, and tightly seal the material.



3-106 90% and 120%

3-107 one per 1500' per 2 lanes

After final rolling, density tests are taken by the O M & R and the results documented. Stabilized bases must be compacted to at least 98% of maximum density (This differs from untreated aggregate base courses that had to be compacted to 100% of maximum density).

FINISHING

After compaction, fine-blading to crown and grade takes place. The motor grader will be brought in to cut the materials to proper grade, which should be achieved by cutting and not drifting materials into low spots.



Once the contractor's people think the base course is to plan grade and crown, you will need to check it. If the base course, other than soil cement or cement stabilized aggregate, is not within tolerance the contractor must rework the materials. You will learn in the last Chapter of this book what is involved in "checking" or measuring the base course for acceptance and just what the tolerances are.

CURING

After a stabilized base course has been compacted and fine bladed, it should be protected against rapid drying for a 7 day curing period. This protection is accomplished by applying an approved grade of prime to the completed base. The curing compound is applied to the section at a minimum rate of 0.15 - 0.30 gallons per square yard.

3-118 35°F

Traffic and equipment should be kept off of the base during the curing period unless specifically permitted. If permitted, any damage caused by traffic will have to be corrected at the contractor's expense!

- 3-113 An approved grade of _____ is used to protect a completed stabilized base course.
- 3-114 The completed base course should be protected against rapid drying for a _____ day curing period.
- 3-115 The curing compound is applied at a minimum rate of _____ gallons per square yard.
- 3-116 Why should traffic and equipment be kept off the base course during curing?
_____.
-

CONSTRUCTION JOINTS

A construction joint should be cut at the beginning of each day's operation, or at approach slabs or the edge of an existing roadway slab. In the case of cutting into existing soil cement, the contractor should cut back (usually with a motor grader) approximately 2 feet or more into the existing material to form the construction joint. In the case of joining an existing concrete slab (when cutting in place), the material should be moved away from the slab by means of a motor grader, mixed, and then bladed back into place.

The construction joint has two purposes:

It assures a good bond between cuts.

It assures continuous soil cement base with no unstabilized material between the end of one cut and the beginning of another.



FILL IN THE BLANK:

- 3-117 To form a construction joint, cut back into an existing soil cement base at least _____.
-

3-124 Tractor
Screed

3-125 20

ASPHALTIC CONCRETE BASE COURSES

Asphaltic concrete base course construction is similar to asphaltic concrete paving with the exception of the type of mixture used. (Remember: Asphaltic Concrete Base or Sand Asphalt Base is used for base course construction). In this section we will present the basic operational information; however, for more detailed information about the equipment and the paving procedures, refer to the Asphalt Paving Inspection course.

To begin construction of an asphaltic concrete base course, the air temperature in the shade away from artificial heat must be in accordance with the following table because in cold weather asphalt base mixture cools quickly.

Thickness (inches)	Minimum Temperature
2.1 – 3	35°F
3.1 – 4	30°F
4.1 – 8	Contractor's Discretion

FILL IN THE BLANK:

3-118 Construction of a 2½-inch layer is halted if the descending air temperature falls below _____.

PLACEMENT

As the inspector you should keep an eye out for mixture deficiencies which may lead to rejection of a truckload of asphaltic concrete.

Some of these deficiencies are:

overheated mix - blue smoke rising from mix

cold mixture - stiff appearance or improper coating of larger aggregate particles

excess asphalt cement in mixture - material lies flat and has extremely shiny appearance; soupy

too little asphalt cement in mixture - granular appearance or improper coating of aggregate

excess coarse aggregate - coarse and rough textured appearance

excess fine aggregate - lean, dull brown with fine textured appearance

excess moisture - steam rising from mix as it's being dumped into paver; may be bubbling as if boiling and may look soupy

segregation - fine aggregates lumped together, and coarse aggregates lumped together

CHOOSE THE BEST ANSWER(S):

3-119 A mix with a dull brown appearance may have:

- a. too much asphalt
- b. excess fine aggregates
- c. contamination

3-120 A mix with improper coating of large aggregates and a stiff appearance may be:

- a. an overheated mixture
- b. a mixture with too much asphalt
- c. a cold mixture

3-121 Blue smoke rising from the truck may indicate:

- a. an overheated mix
- b. a segregated mix
- c. a cold mix

3-122 A mix with excess moisture might:

- a. bubble and pop as if boiling
- b. appear soupy
- c. steam as it's dumped into the paver

3-123 A mixture with too much asphalt cement might:

- a. have a dull brown appearance
- b. have a very shiny appearance and lie flat
- c. have a granular appearance

3-113 Prime

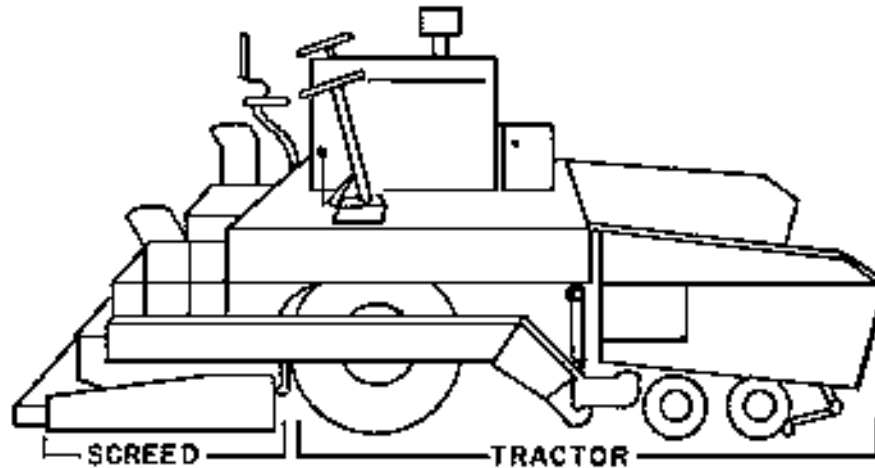
3-114 7

3-115 0.15

3-116 To avoid any damage to the completed base course

3-117 2 feet or more

The tractor portion of the paver receives the hot mix and feeds the mix onto the "augers" which spread the mix across the roadway.



The screed unit of the paver presses down and smoothes the mix. An electronic screed system automatically controls the grade and slope of the base through the use of a "sensor" attached to one of the tow arms.

FILL IN THE BLANK(S):

3-124 The two units of the paver are the _____ unit and the _____ unit.

The mixture spread by the paver, commonly called the "mat", is spread thicker than the plan thickness to allow for compaction. The contractor is responsible for obtaining the plan thickness, so normally he will spread a mat which is about 20% greater than plan thickness. For example, if the plan thickness of the base is 8 inches, then $20\% (.20) \times 8 \text{ inches} = 1.6 \text{ inch}$; therefore, the laydown thickness is 9.6 inches. You learned in Chapter 2 the method for computing the amount by weight of asphaltic concrete needed.

FILL IN THE BLANK(S):

3-125 The contractor will usually spread about _____ percent more mix than plan thickness to allow for compaction.

When you inspect the mat after placement, you should look for several things:

The surface should be black, even, and without any holes.

The texture should appear uniform - not slick in some areas and granular in others.

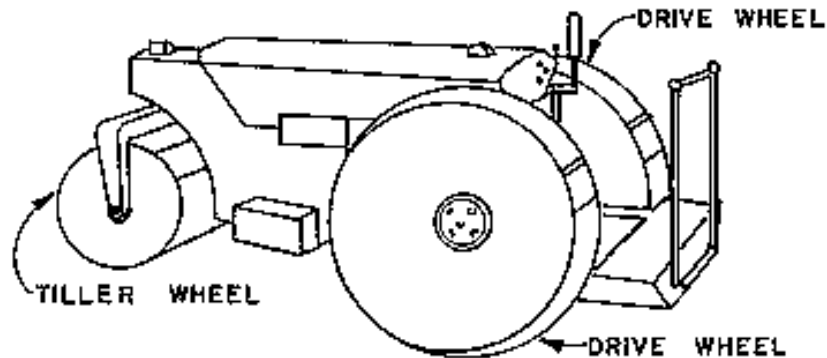
The coarse aggregates should be evenly distributed.

There should be no oily spots.

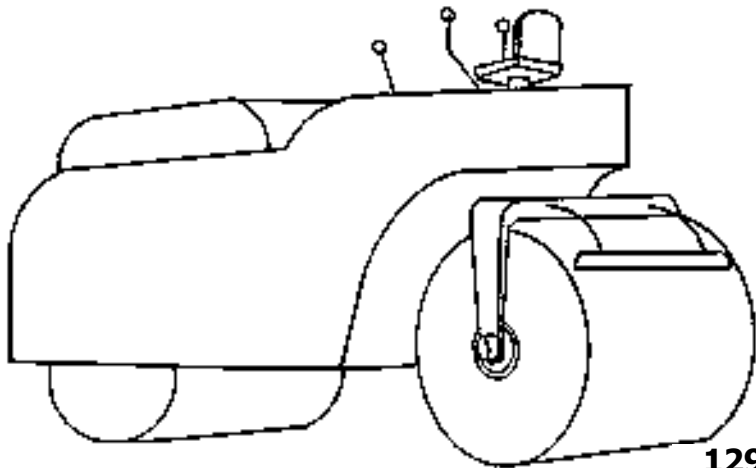
COMPACTION

Compaction of asphaltic concrete is achieved by rolling. Three stages of rolling have traditionally been employed: breakdown rolling, intermediate rolling, and finish rolling. The first two stages achieve the compaction, and the final stage is actually for smoothing the surface of the mat. Until recent years, different rollers were used in each stage of compaction.

Breakdown rolling was achieved by using either a three-wheel roller,



or a tandem roller.



3-119 b. Excess fine aggregates

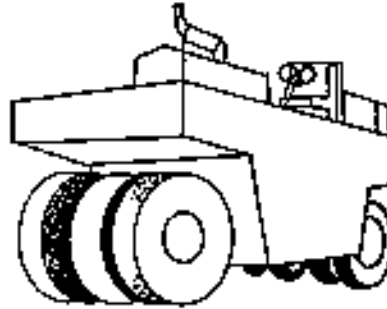
3-120 c. A cold mixture

3-121 a. An overheated mix

3-122 a., b., and c., (All are correct)

3-123 b. Have a very shiny appearance and lie flat

Intermediate rolling was achieved by using a pneumatic roller



3-127 Outside edge
Centerline

3-128 2 to 3 inches

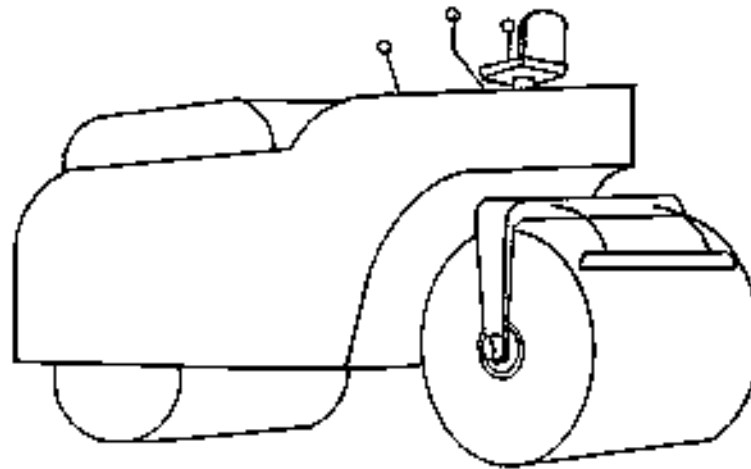
3-129 Along the same path as the
first pass to form one coverage

3-130 The third is made overlap-
ping the previous pass by 6 inches
and the fourth is made over the
same material as the third

3-131 2 to 3 inches

Finish rolling was achieved by using a tandem roller as shown previously.

In recent years; however, the use of one steel wheel roller to achieve the required density has increased, and in particular, the vibratory roller.



The vibratory roller is not only economical to use since only one type of roller is necessary, but it is also efficient. Some models are designed specifically for asphaltic concrete and the problems which can occur with this type of pavement. This roller can also revert to a static mode from the vibratory mode, which is important when changing directions.

The Standard Specifications allow for either the traditional method of using the different rollers to achieve compaction or the more recent method of using one type of rollers-whichever method is sufficient to achieve the required density and surface smoothness. All rollers used shall be self-propelled, in good condition, and capable of maintaining the pace of the paver.

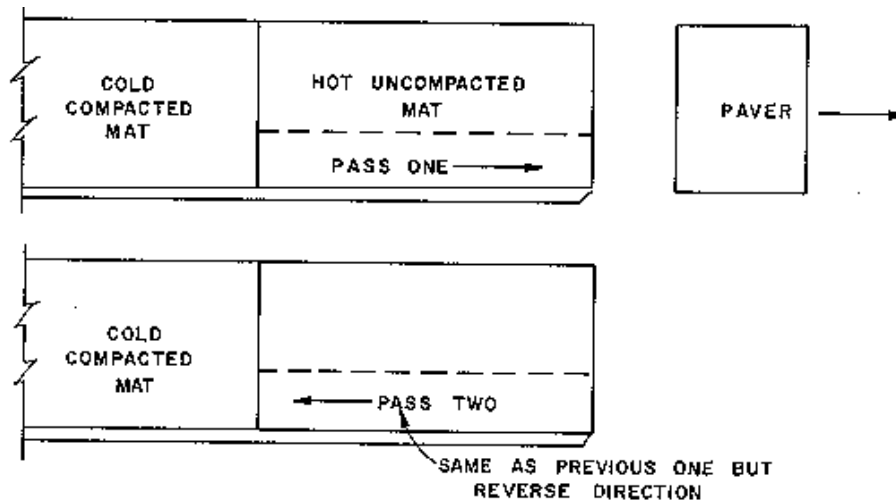
ANSWER THE QUESTION:

3-126 What are some requirements for rollers?

1. _____
2. _____
3. _____

Breakdown rolling should begin as soon as the mat will carry the roller without distorting the mix. The rolling pattern described in the following discussion is one which has traditionally been used with the tandem or three wheel roller; however, suitable rolling patterns may vary, depending on such factors as temperature, properties of the mix, climatic conditions, and the type of job. Control strips are used to try out the contractor's proposed rolling procedures. The Office of Materials and Research usually sets these procedures.

On the first lane, the roller should work from the outside of the mat toward the centerline of the roadway. To begin with the roller should actually overhang the edge of the mix by 2 to 3 inches. One pass in one direction followed by a return pass on the same coverage.



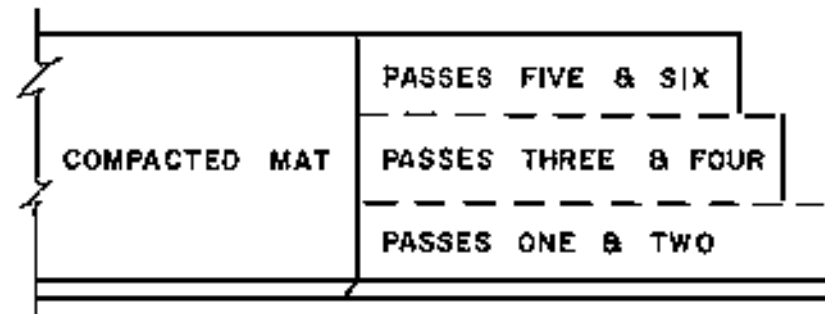
ANSWER THE QUESTION(S):

3-127 On the first pass of breakdown rolling, always work from the _____ edge to the _____.

3-128 The roller should overhang the edge of the mix by _____.

3-129 Where is the second pass made?

The third pass should overlap the previous pass by 6 inches, and the fourth pass is made over the same material as pass three. This pattern is continued until the entire width has been rolled. The final passes should overhang the edge of the mat by 2 to 3 inches.



3-135 Passes overlap, but no two passes are in the exact path as done in breakdown rolling.

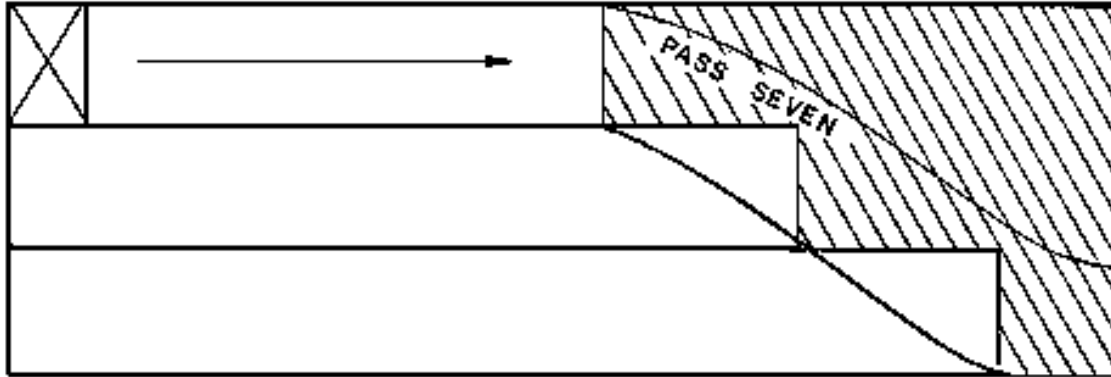
3-136 To obtain surface smoothness

FILL IN THE BLANK(S):

3-130 The third and fourth passes made are made _____.

3-131 The final pass should overhang the edge of the mat by _____.

To get the roller back to the uncompacted mat just placed by the paver, pass seven should cut diagonally across the points where the roller has stopped.



Notice that the places where the roller stops on its passes are staggered. This is done to avoid a continuous dip across the entire width of the mat. By rolling diagonally on pass seven, the dips caused by reversal of the roller on each pass are ironed out.

ANSWER THE QUESTION:

3-132 Where is pass seven made?

Intermediate rolling is done to obtain maximum density. When the pneumatic roller is used for this stage it should start from the outside edge and work in, but it must be kept about 6 inches away from the centerline if only one lane is in place. When both lanes are down, the joint should be overlapped at least 6 inches.

FILL IN THE BLANK(S):

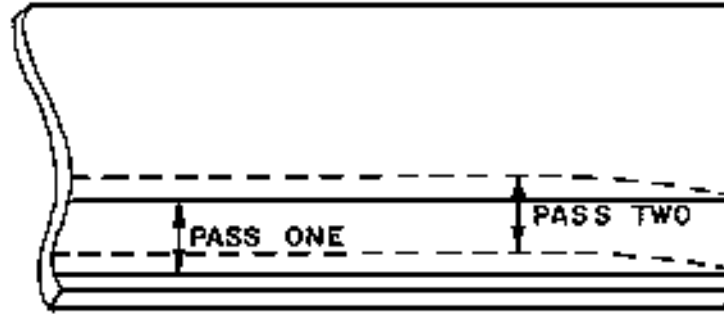
3-133 The highest densification compaction is achieved during _____ rolling.

3-134 If one lane is in place, the pneumatic roller (if used) should be about _____ from the centerline, but if both lanes are down the roller should _____ the centerline about _____.

3-126 Self-propelled
In good condition
Capable of maintaining the
pace of the paver

- 3-139 Tack
Bituminous
- 3-140 Dirty, wet, or frozen
40°F
In accordance with Table
400.05.B. of the Standard
Specifications

The pneumatic roller may take from 7 to 17 passes to cover a lane, but must not over roll the mix. (Vibratory rolling generally requires a fewer number of passes than static rolling). Each pass overlaps the previous pass, but no two passes are in the exact path as was done in breakdown rolling. Notice how these passes overlap.



ANSWER THE QUESTION:

3-135 What is the general pattern of intermediate rolling?

Finish rolling is necessary to obtain surface smoothness and should be carried out when the mix is still workable enough. A rolling pattern similar to that of the intermediate rolling pattern is used. When vibratory rollers are used instead of tandem rollers, the roller will be switched to a static mode for finish rolling.

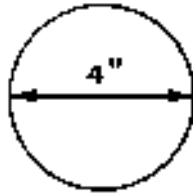
3-136 The purpose of finish rolling is _____.

Some rules to follow to obtain good results at rolling are:

- Perform compaction at a suitable temperature range.
 - Change directions slowly and smoothly (and with vibrations off if a vibratory roller is used).
 - Do not allow roller to stand on the hot mat.
 - Avoid stopping the roller in the same transverse location after each stop.
 - Avoid abrupt turns.
-

You remember that with unstabilized aggregate and stabilized base courses, certain density requirements have to be met after compaction. The same is true for asphaltic concrete base courses. Upon completion of all rolling procedures, samples are taken for density testing. As the inspector you should be present while this sampling takes place.

The linear feet of asphaltic base course laid each day is subdivided into five sections of equal length, and one sample is taken from each section. The size of each sample should be approximately 4 inches in diameter.



FILL IN THE BLANK(S):

3-137 _____ samples are taken each day, each of which is _____ inches in diameter.

According to the Standard Specifications, the average of the five tests must be a minimum of 97.5% of the control strip density. The control strip density must equal or exceed 94% of the voidless mix density when the mix is tested by AASHTO: T-245 (Marshall Specimens).

FILL IN THE BLANK(S):

3-138 The _____ of five samples must be at least _____ percent of _____.

You should receive the results of your samples the day they are taken. All results should be documented in your field book just as for soil aggregate and stabilized bases. Any section that is deficient should be corrected or replaced, and the corrective action documented.

3-132 Diagonally across the points where the roller has stopped

3-133 Intermediate

3-134 6 inches
Overlap
6 inches

- 3-144 Kraft paper
- 3-145 Subgrade
- 3-146 90°
- 3-147 Tack
- 3-148 Screed
- 3-149 Spreading

FINISHING - APPLYING THE TACK COAT

Upon completion, an asphaltic concrete base course shall be coated with tack, which is also a bituminous material. The tack coat may be viscosity grade AC-10, AC-20 or AC-3Q; or cationic emulsified asphalt grade CRS-2h or CRS-3 may be used.

FILL IN THE BLANK(S):

3-139 An asphaltic concrete base course is finished by applying a _____ coat that is a _____ material.

Some rules concerning the application of tack are:

Never apply tack to a dirty, wet or frozen surface.

Apply emulsified asphalt tack only when the temperature is above 40°F.

Any time asphalt concrete can be placed in accordance with Table 400.05B of Standard Specifications, Asphalt Cement tack may also be applied.

TABLE 400.05.B

Lift Thickness	Minimum Temperature
1 inch or less	55°F
1.1 inches to 2 inches	45° F
2.1 inches to 3 inches	35° F
3.1 inches to 4 inches	30° F
4.1 inches to 8 inches	Contractor's Discretion

FILL IN THE BLANK(S):

3-140 You should never apply tack to a _____ surface, when the temperature is below _____ for emulsified asphalt. Asphalt Cement tack may be applied _____.

Tack should be uniformly spread by an asphalt distributor at a rate established by the Engineer, according to the ranges set forth in the Specification Book. Too much tack may cause the surface course to slide instead of bond to the base course. Also, if the asphaltic base course absorbs extra tack, the base could lose stability.

The measurement of gallons per square yard is converted to liters at 60°F. We will not go into detail again here on conversion.

FILL IN THE BLANK:

3-141 If too much tack is applied to the base course _____.

3-142 The rate of application of tack is established _____.

3-143 The gallons of tack used is converted to gallons at _____ degrees Fahrenheit.

You will need to document the information dealing with tack coat in either a field book or on the source documentation. Do this in the same manner as you documented a prime coat.

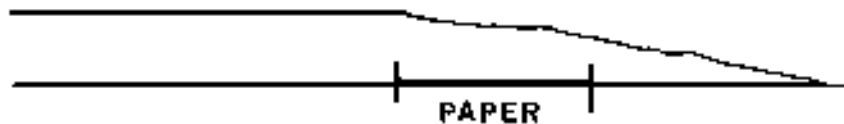
CONSTRUCTION JOINTS

At the end of the day's operations you will need to inspect the construction of the transverse joint at which the next day's operations will begin. You can get a more detailed description of the procedure in the Asphalt Paving Inspection course, but here are the basics:

Kraft paper is laid along all the top and face of the vertical joint

The remainder of the mix from the paver is run out over the piece of Kraft paper in front of the vertical face of the joint.

The mix is then tapered to the subgrade and compacted.



3-137 Five
4

3-138 Average
97.5% of control strip density

- 3-151 Separate construction
- 3-152 Premixed and deposited
- 3-153 Shoulder spreader
- 3-154 Construction of shoulders and base course at the same time and in one continuous unit

At the start of the base course construction the next day you will inspect the following procedures:

The paper and tapered mix are removed and a butt joint 90° with the pavement surface should be left. Make sure that the surface of the mat is smooth and parallel to the surface.

The edge of the mat and the joint face is coated with tack.

The screed of the paver is placed above the compacted mix to a height that will compact even with the previous day's work.

Spreading is begun.

FILL IN THE BLANK(S):

3-144 Let the mix run out on the _____.

3-145 Taper mix to _____ and compact.

3-146 Cut a butt joint _____ to the pavement surface and remove the taper and paper.

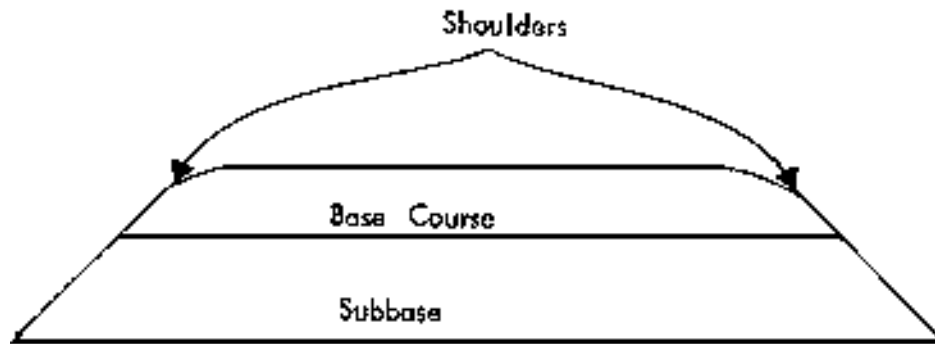
3-147 Coat the edge of the mat with _____.

3-148 Place the _____ parallel to the pavement surface at a height that will compact to the same height as the previous day's work.

3-149 Begin _____.

SHOULDER CONSTRUCTION

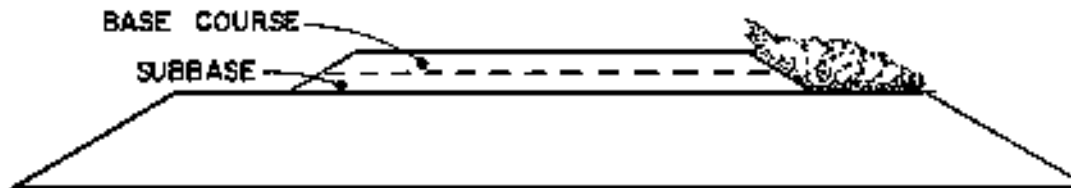
Depending on the project plans and specifications, the shoulder bases will either be constructed at the same time as the base course or after the base course has been completed. Monolithic construction is the term used when the shoulders and the base course are constructed at the same time and form one unit.



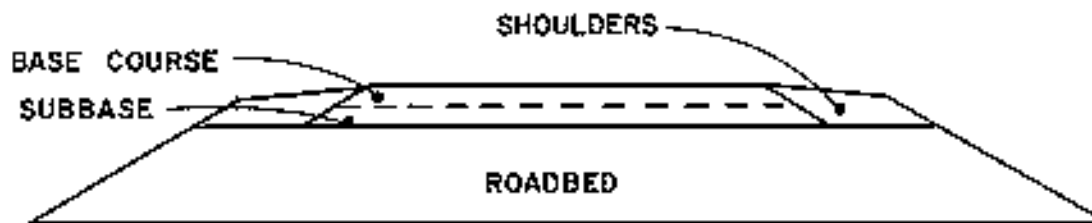
FILL IN THE BLANK(S):

3-150 _____ construction refers to the construction of shoulders and base course as one unit.

Separate construction refers to the construction of the shoulders after the base course has been completed. Generally, the shoulder material that is placed will be premixed and deposited with a shoulder spreader off the edge of the base course.



Then the shoulder material will be compacted and finished to conform to plan typical section.



3-141 The surface course will slide

3-142 By the Engineer

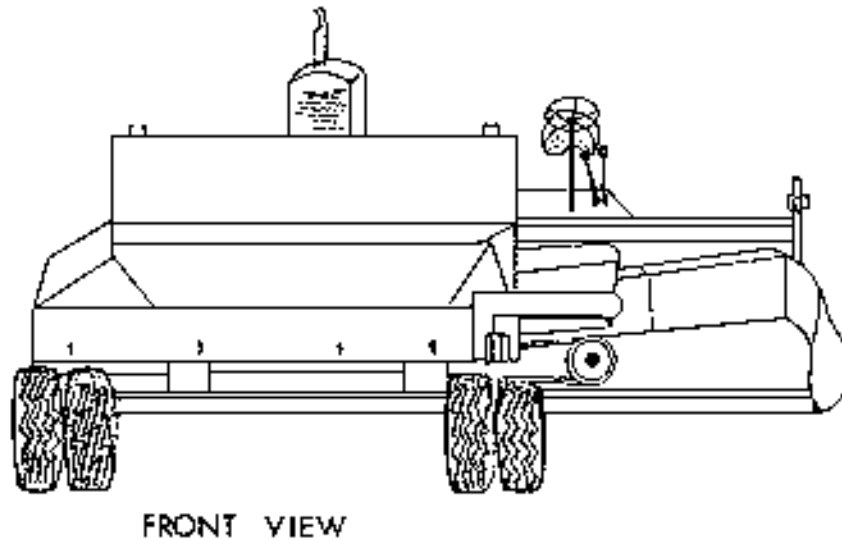
3-143 60

FILL IN THE BLANK(S):

3-151 Construction of the shoulders after the base course, in separate operations, is termed _____.

3-152 Usually the shoulder material will have been _____ and ready for placement.

The shoulder spreader as mentioned previously operates by running on top of the base course depositing shoulder material off the edge.



After placement, the shoulder material is then shaped, compacted, and fine-bladed. Also, if required, the shoulders will be protected with the specified asphaltic material.

FILL IN THE BLANK(S):

3-153 The _____ is used for placement of shoulder material.

3-154 Monolithic construction is _____.

3-155 Separate construction is _____

CHAPTER 3 REVIEW

CIRCLE THE CORRECT ANSWER:

- 3-156** Construction of a base course in one lift is termed:
- a. single operation
 - b. separate construction
 - c. monolithic construction
 - d. multi-layered construction
- 3-157** The process of one lift sliding after being placed upon a lift that is too smooth can cause:
- a. breakage
 - b. shifting
 - c. sliding
 - d. separation
- 3-158** The minimum amount of prepared subgrade that should be in final condition to receive the base course is:
- a. 500 feet
 - b. 1,000 feet
 - c. 1,500 feet
 - d. 300 feet
 - e. none specified
- 3-159** The piece of equipment used for mixing untreated aggregates on the roadway is the:
- a. spreader box
 - b. haul truck
 - c. grade-all
 - d. motor grader
- 3-160** Which of the following items have certain requirements which an untreated aggregate mixture must meet after being mixed:
- a. mixture uniformity
 - b. gradation
 - c. moisture content
 - d. shape of the lifts

3-150 Monolithic

3-173 b. Segregation

3-174 a. Rollers should change
directions slowly and smoothly
b. Abrupt turns should be
avoided

3-175 b. Maximum density

3-176 b. 60°F

3-177 Monolithic construction

3-178 Sampling, Testing, and
Inspection Manual

3-161 One of the most effective pieces of equipment used to compact materials spread in thick lifts is the:
a. sheepfoot roller
b. pneumatic roller
c. vibratory roller
d. waffle-wheel roller

3-162 Equipment which does not penetrate to the bottom of a lift leaving it uncompacted and loose is causing:
a. shifting
b. planing
c. bridging
d. separation

3-163 The piece of equipment often used to compact granular material is the:
a. pneumatic roller
b. sheepfoot roller
c. vibratory roller
d. waffle-wheel roller

3-164 Untreated aggregate base courses must reach what percentage of maximum density?
a. 95%
b. 98%
c. 85%
d. 100%

3-165 If a failing density test occurs, two additional tests should be taken within what radius of the failing test?
a. 2 feet
b. 5 feet
c. 8 feet
d. 10 feet

3-166 The defect which occurs when prime is stripped off and fines are worn away is called:
a. bridging
b. raveling
c. separation
d. planing

- 3-167** To begin construction of a stabilized base, the ascending (rising) air temperature must be:
- 35°F
 - 40°F
 - 45°F
 - 50°F
- 3-168** The piece of equipment used to mix cement with untreated aggregate on the roadway is the:
- motor grader
 - pugmill
 - mixer
 - pneumatic roller
- 3-169** At the time of compaction the actual moisture content of the stabilized base course should not vary from the specified optimum moisture content by more than:
- 100 - 120%
 - 90 - 120%
 - 90 - 100%
 - 80 - 50%
- 3-170** Stabilized base courses must reach what percentage of maximum density?
- 100%
 - 98%
 - 95%
 - 93%
- 3-171** A stabilized base course should be protected against rapid drying by applying an emulsified or cutback asphalt for a curing period of:
- 24 hours
 - 43 hours
 - 72 hours
 - 7 days
- 3-172** To begin construction of an asphaltic concrete base course, the air temperature in the shade must be above:
- 35°F
 - 40°F
 - 45°F
 - 50°F
- 3-155 Construction of the shoulders after the base course has been completed.
- 3-156 c. Monolithic construction
- 3-157 c. Sliding
- 3-158 e. None specified
- 3-159 d. Motor grader
- 3-160 a. Mixture uniformity

4-1 ½-inch
 3,000 FT.
 ½-inch

- 3-173** A deficiency of an asphaltic concrete mixture in which fine aggregates are lumped together and coarse aggregates are lumped together is called:
- a. separation
 - b. segregation
 - c. contamination
 - d. bridging
- 3-174** Which of the following items are good rules to observe in rolling asphaltic concrete?
- a. Rollers should change directions slowly and smoothly.
 - b. Abrupt turns should be avoided.
 - c. Rollers should be stopped in approximately the same transverse location after each pass.
 - d. Vibrators of vibratory rollers should always be "on" during rolling.
- 3-175** Intermediate rolling is done to obtain:
- a. surface smoothness
 - b. maximum density
 - c. the breaking down of the mixture
- 3-176** To apply a tack coat, the measurement of gallon per square yard is converted to gallons at:
- a. 50°F
 - b. 60°F
 - c. 70°F
 - d. 80°F
- 3-177** Construction of shoulders and base course in one operation is called:
- a. monolithic construction
 - b. single unit construction
 - c. separate construction
 - d. continuous construction
- 3-178** The procedure for determining random locations for testing is found in the:
- a. Materials Sampling Manual
 - b. Testing Procedures Manual
 - c. Sampling, Testing and Inspection Manual
 - d. Field Construction Manual

- 3-179** The recommended moisture content and theoretical maximum density for the particular base course material are provided by the:
- a. Project Manager
 - b. Central Laboratory
 - c. Design Engineer
 - d. Headquarters

ARRANGE THESE IN ORDER BY PLACING THE APPROPRIATE NUMBERS IN THE BLANK:

3-180

- _____ A The mixture is sweetened.
- _____ B Pit-run material is dumped and spread on the roadway.
- _____ C The material meets specifications and is accepted.
- _____ D The material is sampled and tested after necessary amounts of deficient materials have been added.
- _____ E The material is sampled and tested to see if gradation is within tolerance. The sample fails.
- _____ F Check samples are taken, but the check samples fail.

CALCULATE THE ANSWER:

3-181

The width of the plan surface = 25 feet
Prime is to be shot from Station 85+00 to Station 90+00
Beginning Quantity = 2,000 gallons
Ending Quantity = 1,618 gallons
Approximate temperature = 136°F (The conversion factor for this temperature = 0.9701).

Answer _____ gallons per square yard

- 3-167 b. 40°F
- 3-168 c. Mixer
- 3-169 b. 90 - 120%
- 3-170 b. 98%
- 3-171 d. 7 days
- 3-172 b. 40°F

CHAPTER 4:

BASE COURSE ACCEPTANCE

DIMENSIONAL MEASUREMENTS

When a base course is completed it should conform to plan typical section, and the way we determine this is by measuring. We have again designated the section divisions as the main base course types, but under each type of base course, the following topics are discussed:

4-4 3
 Thickness
 Measuring stick
 Straightedge

thickness and width requirements
methods of measurement
documentation

4-5 Stretching a metallic tape
 from outside edge to outside edge
 of the completed base

Thickness and width requirements are based on the appropriate base specification of the Standard Specifications. The methods and documentation are explained in detail in the Sampling, Testing, and Inspection Manual, Volume 1.

As the roadway inspector, you will not actually be taking acceptance measurements, as the District Lab does this; however, you should be familiar with all processes concerning the base course. The District Lab is measuring a base course that you have inspected.

RAW, UNTREATED AGGREGATE BASE COURSES

For any individual thickness test, the tolerance amount for under thickness of untreated aggregate base courses is ½-inch. Over thickness of untreated aggregate base courses is waived at no additional cost to the Department. The average of individual tests in any 3,000-foot section of a base must not be less than ½-inch of the thickness shown on the plans.

FILL IN THE BLANK(S):

4-1 For an individual test, an untreated aggregate base course must not exceed a tolerance of _____ for under thickness. The average of tests in any _____ section of the completed base must not be less than _____ of plan thickness.

If an area shows an under thickness deficiency beyond the ½-inch, the contractor must correct the area by furnishing, placing, and compacting additional materials as required to bring the area to plan dimension. This must be done at no additional cost to the Department.

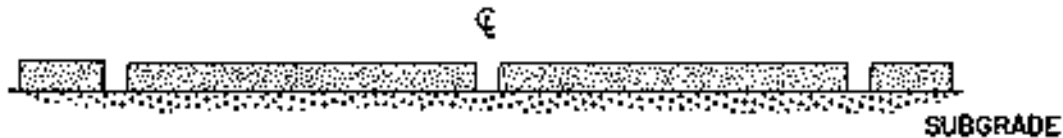
- 4-2** If the plan thickness of a raw base is 7 inches, which of the following measurements are within the tolerance?
- a. 6 inches
 - b. 6½ inches
 - c. 6¾ inches

An untreated aggregate base course should not vary from plan width in excess of 6 inches. Over widths are waived at no additional cost to the Department. Under widths in excess of the tolerance are corrected at the contractor's expense by placing, shaping, and compacting additional base course material as needed.

CIRCLE THE CORRECT ANSWER(S):

- 4-3** The plan width of an untreated aggregate base course is 24 feet. If the actual width is 24 feet 7½ inches, the base (is/is not) acceptable. If the actual width is 23½ feet, the base (is/is not) acceptable. However, if the actual width is 23 feet, the base (is/is not) acceptable.

The thickness of an untreated aggregate base course must be measured at random locations to represent each 1,500-foot section of completed base. The thickness is determined from holes dug through the base to the subgrade. Three holes are dug across the roadway as indicated below:



3-179 Central Laboratory

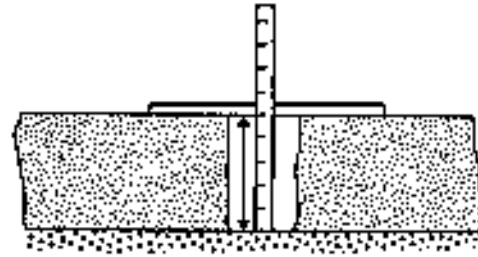
- 3-180 A. 4
B. 1
C. 6
D. 5
E. 2
F. 3

3-181 0.27 gallons per square yard

4-7 Replaced

4-8 Furnishing and placing a supplemental layer of asphaltic concrete

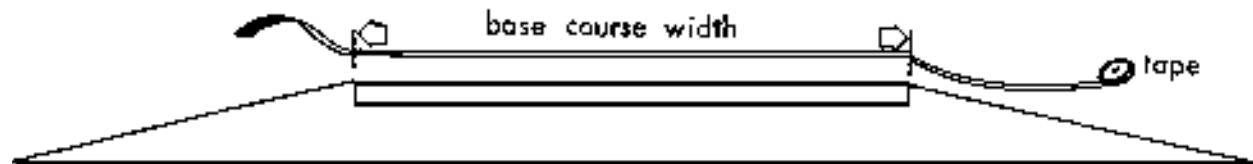
The depth of these holes is then checked by means of a straightedge and measuring stick as shown below.



FILL IN THE BLANK(S):

4-4 _____ holes are dug across the base to measure the _____. A _____ is inserted to the bottom of the base, and a _____ is placed across the top of the hole.

The width of an untreated aggregate base course should be checked at the same time and in the same location that thickness determinations are made. Measurements are taken by stretching a metallic tape from outside edge to outside edge of the compacted base.



FILL IN THE BLANK(S):

4-5 Width measurements are made by _____

DOCUMENTING ACCEPTANCE MEASUREMENTS

All measurements of thickness will be recorded to the nearest 1/4-inch, and all measurements of width will be recorded to the nearest inch. The following illustration is an example of documenting measurements of thickness and width.

STA.	LOC.	THEO. THICK	ACT. THICK.	THEO. WIDTH	ACT. WIDTH	DATE	INI.
16	8' R.	8"	8 1/2"			8-10-77	J.H.H.
16	C	8"	8 1/4"	22'	22'	8-10-77	J.H.H.
16	8' L.	8"	8 1/2"			8-10-77	J.H.H.

4-2

C

4-3

Is

Is

Is not

Just as an untreated aggregate base course has to meet certain requirements for acceptance, a stabilized base course must also meet certain specifications before being approved. Let's talk about these requirements.

STABILIZED BASE COURSE

For any individual thickness test the tolerance amount for under thickness of stabilized bases is 1/2-inch. The allowance for over thickness is 1/2-inch. The average of individual tests in any 1/2-mile section of a base must not vary in excess of 1/2-inch from the thickness shown on the plans.

FILL IN THE BLANK(S):

- 4-6 For an individual thickness test, a stabilized base course must not exceed a tolerance of _____ for under thickness. A stabilized base must not exceed a tolerance of _____ for over thickness.

If areas show deficiencies beyond the tolerances, the contractor must correct them at no additional costs to the Department. If the Engineer will not permit any grade adjustments, the areas must be removed to the full depth of the course and reconstructed to the required thickness.

If the Engineer does permit grade adjustments, the contractor may correct thickness deficiencies by furnishing and placing a supplemental layer of asphaltic concrete instead of removing and replacing the deficient base course.

4-10 Inserting a measuring stick into the hole to the point where the color change begins; a straightedge is placed across the hole and the measurement is taken

4-11 The 3 measurements taken

FILL IN THE BLANK(S):

4-7 If the Engineer does not allow grade adjustments to correct deficiencies, the areas must be _____ with material meeting the required specifications.

4-8 If the Engineer does allow grade adjustments, the area is corrected by _____.

Stabilized bases should not vary from the plan width in excess of 6 inches. Over widths of pugmilled materials (in excess of the tolerance) if paid for by the square yard are waived; however, over widths of mixed-in-place materials must be corrected. If grade adjustments are not permitted the full depth and width of the base course in the area of the over width shall be removed and replaced with the same type of base course. If grade adjustments are permitted, the contractor will correct the over width deficiency by placing supplemental layer of asphaltic concrete to the entire width of the section.

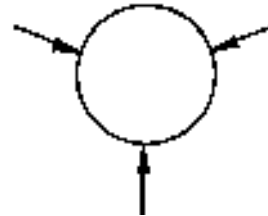
Under widths in excess of the tolerance shall be corrected to plan width by placing additional materials (one of the materials listed above). The width of the widening materials shall not be less than 12 inches.

You learned from Chapter 3 in the section on stabilized bases that control measurements of thickness (depth) and width are taken either:

prior to compaction if the materials are mixed-in-place, or
prior to placement if pugmilled materials are used.

The District Lab takes the acceptance measurements within 7 days after completion of the base course. The measurements are taken at random locations to represent each 1,500-foot section of the completed base.

Thickness is checked by digging three randomly spaced holes across the base to the subgrade. Three measurements are taken within each hole, evenly spaced around the perimeter.



The average of these measurements within a hole is the reported depth measurement. Using chemicals that turn dark red on contact with materials of high calcium content can also check thickness. (Cement has high calcium content).

Three holes are dug to the subgrade across the compacted base. The sides of each hole are scraped clean, and all loose material is removed. The chemical is squirted into the hole by means of a squirt bottle, starting at the bottom of the hole to the top in three different places, approximately 120° apart.



4-6 1/2-inch
 1/2-inch

FILL IN THE BLANK(S):

4-9 Certain chemicals turn _____ upon contact with materials of high
 _____ content.

4-13 Yes

4-14 Average

A measuring stick is inserted into the hole to the point where the color change begins. A measurement is then taken by placing a straightedge across the hole. Each of the three lines of the chemical is measured, and the average of the three measurements is documented as the actual depth at that point.



FILL IN THE BLANK(S):

4-10 The actual measurement of thickness after applying the chemical is done by _____.

4-11 The measurement recorded is an average of _____.

One method of measuring the width of the completed base is by using the same process used for control measurements; that is, locating the outside edges of the base and using a metallic tape to measure the width. You will probably have to cut into the outside edges of the base to locate the point where the fully stabilized base begins.

Their color and hardness can be used to recognize stabilized materials. This method of measuring width is not as reliable as the method described that follows.

The same type of chemical used to measure depth should be used to measure width. The outside edges of the compacted base course materials are cut away until the complete depth of the base course is exposed. (These must be vertical cuts.) The chemical is squirted on the edges from the bottom up. If the color change does not indicate that the base is stabilized to the proper depth at that point, you must cut further into the base until the chemical indicates that you have located the edge of the fully stabilized material. Once you have located the outside edges of the stabilized materials, use a metallic tape to measure from side to side.

GIVE THE INFORMATION:

4-12 Two ways of determining the width of a stabilized base are:

A. _____

B. _____

4-9 Red
Calcium

DOCUMENTING ACCEPTANCE MEASUREMENTS

The following is an example of documenting measurements of thickness and width.

STA.	LOC.	THEO. THICK.	ACT. THICK.	THEO. WIDTH	ACT. WIDTH	% CEMENT	DATE	INI.
21	GRA	6"	6 $\frac{1}{2}$ "			8%	6/9/77	R28
21	E	6"	6 $\frac{3}{4}$ "	22'	22'-6"	8%	6/9/77	R28
21	G'LA	6"	6 $\frac{1}{2}$ "			8%	6/9/77	R28

Notice that the only difference between documenting raw and stabilized bases is that the percentage of cement is added for stabilized bases.

ANSWER THE QUESTION:

4-13 Are the actual thickness and width in tolerance? (See Part 1: Dimensional Requirements, if you are not sure).

The District Lab takes acceptance measurements within 7 days after completion of the base course. The measurements are checked at random locations to represent each 1,500-foot section.

The first step in determining the thickness of stabilized base courses is to dig three holes across the roadway down to the subgrade. Then, using a measuring stick and a straightedge, check the depth in three different places in each hole, approximately 120° apart.

The average of the three measurements within the same hole is the actual measurement documented.

FILL IN THE BLANK(S):

4-14 The measurement documented as the thickness of the stabilized base is actually the _____ of the three measurements taken within each hole.

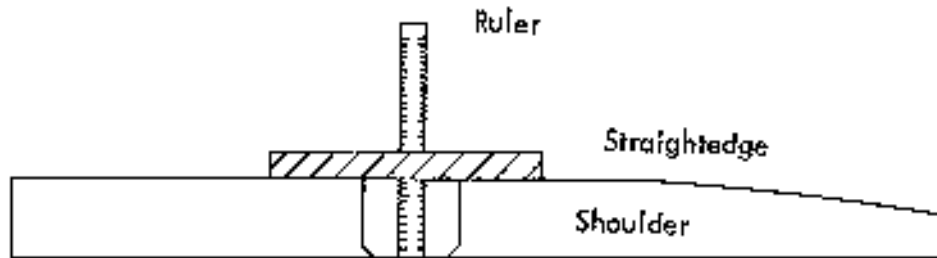
Using a metallic measuring tape, measure the complete width of the roadway from outside edge to outside edge.

DOCUMENTING ACCEPTANCE MEASUREMENTS

Document the acceptance measurements for stabilized base courses just as you would an untreated aggregate base.

STA.	LOC.	THEO. THICK.	ACT. THICK.	THEO. WIDTH	ACT. WIDTH	DATE	INI.
16	8' Rt.	8"	8 $\frac{1}{2}$ "			8-10-77	J.H.P.
16	E	8"	8 $\frac{1}{4}$ "	22'	22'	8-10-77	J.H.P.
16	8' Lt.	8"	8 $\frac{1}{2}$ "			8-10-77	J.H.P.

Thickness measurements on shoulders are generally taken in the same manner as are measurements for a normal section; however, it is necessary only to dig one or two holes across the shoulder, depending on the width.



The width of the shoulder base should not vary from plan width in excess of 3 inches. Width is checked by using a metallic measuring tape.

4-15 The tolerance for shoulder width is _____.

CHAPTER 4 REVIEW

ANSWER THE QUESTION:

- 4-16 Who is responsible for taking acceptance measurements?
- 4-17 Over thickness' of untreated aggregate base courses are waived. What must be done for under thickness' beyond the tolerance?
- 4-18 How are thickness and width of an untreated aggregate base course measured for acceptance?

thickness

width

4-12 A. Determine by color and hardness the point where the fully stabilized base begins; then measure with a metallic tape

B. Use a chemical to determine the point where stabilization begins; then measure with a metallic tape

- 4-19** The treatment of over widths varies, depending on whether or not grade adjustments are permitted. Under widths; however, must be corrected by _____
- 4-20** How are chemicals used to determine thickness of stabilized base courses?
- 4-21** How are over thickness' of stabilized base courses treated?
- 4-22** What procedure is used to measure thickness on shoulders?
-

4-15 3 inches

4-16 The Central Lab

4-17 The contractor must furnish, place, and compact additional materials to bring the area to plan dimension

4-18 A. Three holes are dug across the roadway down to the subgrade. The depth is then checked by means of a straightedge and measuring stick

B. A metallic tape is stretched from outside edge to outside edge of the compacted base